CUNNINGHAMIA

A journal of plant ecology for eastern Australia

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COVER

Over 70% of the natural forests and woodlands in the Guyra region of the New England Tableland have been cleared. However, a variegated landscape remains, composed of dense forests on hills with siliceous soils and scattered clumps of woodland in the valleys with higher nutrient soils. These remnants form a basis for future revegetation of parts of the landscape (Illustration by Catherine Wardrop).

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CONTENTS

Vegetation Survey of the Barrington Tops and Mount Royal National Parks for use in Fire Management **Toivo Zoete** 511

Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation **Lynette C. McLoughlin** 579

Surveys of areas having potentially high botanical diversity near Pooncarie, South Far Western Plains **AnneMarie Clements, Tony Rodd, Rosalind J. Moore, Adele G. Crane and John Simpson** 611

Vegetation and flora of Booti Booti National Park and Yahoo Nature Reserve, lower North Coast of New South Wales. **S.J. Griffith, R. Wilson and K. Maryott-Brown** 645

Vegetation, soils and management of 'Zara': a sandhill remnant on the Riverine Plain **M.J. Stafford and D.J. Eldridge** 717

Vegetation of the Guyra 1: 100 000 map sheet New England Bioregion, New South Wales **J.S. Benson and E.M. Ashby** 747

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Vegetation Survey of the Barrington Tops and Mount Royal National Parks for use in Fire Management

Toivo Zoete

Zoete, T. (ERM, 24 Falcon Street, Crows Nest NSW 2065 Australia) 2000. Vegetation Survey of the Barrington Tops and Mount Royal National Parks for use in Fire Management. Cunninghamia *6(3): 511–578.* This paper reports on a vegetation study undertaken to enable the development of appropriate fire management strategies for the conservation of biodiversity. The approach taken is to relate fire response mechanisms reported for species within the literature to floristic patterns.

Floristic and environmental data were obtained from the National Parks and Wildlife Service. The data set was derived from 262 plots located within and around the study area. Data were analysed using classification, ordination, one way non-parametric analysis of variance, and correlation routines contained within the PATN computer package.

On the basis of this analysis, 14 Vegetation Communities were delineated including 12 non-rainforest communities. There was a strong relationship between the floristic pattern and a number of environmental variables, including altitude, climatic variables, geographic location, and geology. 'Years Since Logging' and 'Years Since Last Fire' were also relatively highly correlated, but much of this data is based on subjective field estimates in relatively few sites, often several years after a fire had occurred and is therefore less reliable.

The relationships between floristic data and known plant fire response mechanisms, were generally weak, though significant. The weakness of the correlation is probably due to the lack of information on fire response for many species. On the basis of the existing data base, preliminary guidelines are provided on the nature of suitable fire regimes. Suggestions are given for further study of the floristic pattern, fire history, and other data required to guide ecological fire management in the future.

Introduction

This vegetation study was conducted to provide information to the National Parks and Wildlife Service (NPWS) for the development of appropriate fire management strategies for the conservation of biodiversity within the Barrington Tops and Mount Royal National Parks. The study area for this project encompasses all of the two National Parks as well as areas adjacent to these Parks for which data were available. Emphasis was on the fire adapted vegetation (i.e. non-rainforest vegetation).

The overall approach taken was to relate fire response mechanisms reported for species within the literature (summarised in the National Plant Fire Response Register — Gill & Bradstock 1992) to floristic patterns.

Study area

The Barrington Tops and Mount Royal National Parks cover an area of approximately 67 530 ha, and are located about 100 km north-west of Newcastle, between the towns of Scone and Gloucester (Fig. 1). The Parks are oriented around two plateaux, including the Barrington Tops and the Gloucester Tops plateaux. Together they occupy the southern end of the Mount Royal Range, which runs from the Great Escarpment and the Liverpool Range towards the south-east. The Tops separate the valleys of the upper Hunter River and its tributaries from the valleys of the Manning River. Altitudes vary from less than 200 m asl in the south-eastern part of Barrington Tops National Park to over 1500 m asl on the main plateau in the northern section of that Park.

Considerable climatic variation exists within the study area, concordant with the rugged topography (CMPS&F 1995). Climate ranges from cool temperate conditions at higher altitudes to warm temperate conditions at lower altitudes. The climate is generally sub-humid, although rainfall varies with altitude and longitude. Areas on the lower slopes are generally drier, with mean annual rainfalls of approximately 1000 mm, while areas in the rain shadow of the plateau further inland are driest with a mean annual rainfall of less than 700 mm. On the other hand, areas over 700 m elevation experience a mean annual precipitation of up to 2000 mm. Much of the precipitation at higher elevations is in the form of heavy moist fogs or snowfalls

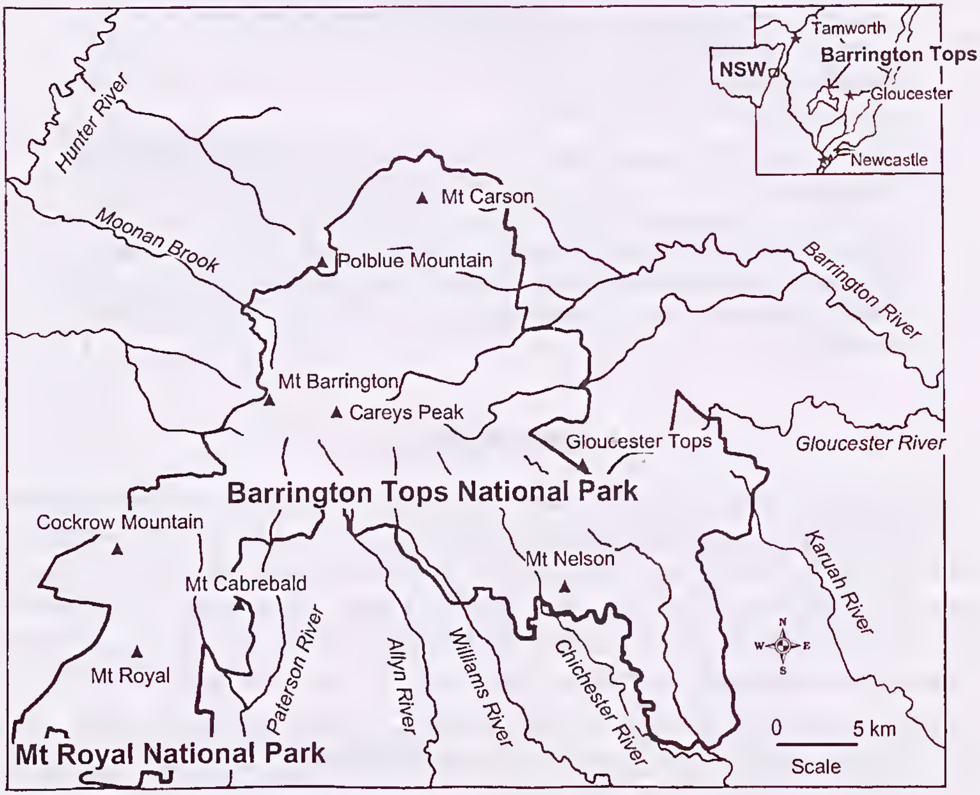

Fig. 1. The study area.

during winter. Up to five snowfalls occur at elevations over 1100 m asl, although most falls are light (10–20 cm depth). Freak snowfalls occur down to 300 m asl approximately once per five years. Rainfall is greatest during the warmer summer months, while late autumn and spring are the driest seasons. Temperatures in surrounding lowland vary from a mean maximum of approximately 23–24°C to a mean minimum of approximately 10–11°C. At higher elevations, temperatures are 5–7 degrees lower than in the valleys, with a minimum of -17°C recorded at 1500 m asl.

Winds tend from the west during July, August and September. Coupled with low rainfall, these winds can provide fire danger conditions in late winter and spring. During October to December winds tend further from the north, resulting in warmer temperatures. If below average rainfalls are experienced during these periods, extreme fire danger conditions can develop. Close to the escarpment, mountain winds (föhn) have a pronounced influence on the behaviour of fire due to their high velocity. Generally, the higher areas of the study area are low fire risks due to the extended cool and moist conditions experienced here (C. Howard, pers. comm.). At lower altitudes, moist conditions in rainforest areas provide barriers to the spread of fire. Generally, fire travels only along the drier ridge lines at lower altitudes, due to moister conditions on the slopes and valleys below.

Three parent rock types with corresponding soil types are found within the boundaries of the study area (Veness & Associates 1995). The oldest rocks date from the Carboniferous Period and consist of an undifferentiated mixture of fine-grained quartz-poor lithic sandstone, conglomerate, siltstone, mudstone, and pyroclastics. This type of rock underlies most of the lower slopes of the study area. Soils developed on these rocks contain friable, usually stony surfaces with abundant organic materials. Both top-soils and sub-soils are generally stony and pedal. Acidity varies from weak to moderate in the top-soil to weak to strong in the sub-soil. Soil depth ranges from 19 cm to over 120 cm.

Granodiorite intruded the landscape in the Middle Permian Period, and presently remain in the Barrington tops area. Soils developed on granodiorite are friable with scattered granodiorite stones. Top-soils are weakly to moderately acid, but sub-soils are moderately to strongly acid. Soil depth varies from 58 cm to over 130 cm.

Intense volcanic activity during the Tertiary resulted in lava flow which settled in the valleys and formed protective caps for the underlying (Carboniferous) sediments. Extensive weathering has since eroded the surrounding hills, resulting in an inverse landscape with the volcanic basalt rocks presently remaining in the highest parts of the plateaux. Soils developed on Tertiary basalt are friable, strongly pedal, and contain organic material and stones. Top-soils are weakly acid and sub-soils are moderately to strongly acid. Soil depth varies from 72 cm to over 100 cm.

Previous flora studies in the study area

The vegetation of the Barrington Tops plateau has been the subject of numerous plant collecting excursions since the early twentieth century. Detailed study of the area commenced around 1915 (Adam 1987). However, it was not until 1937 that Fraser and

Vickery began publishing the first and, so far, only comprehensive published description of the vegetation of the plateau (Fraser & Vickery 1937, 1938, 1939). Other, unpublished, accounts of the vegetation on plateau proper include the study of Mort (1983) on sub-alpine wetland vegetation and Waterhouse (1986, 1988) on broom *(Cytisus scoparius)* infestations. A more recent study of the rare and threatened flora on the plateau is provided by Heinrich and Dowling (1998).

Other surveys and descriptions have primarily focussed on rainforest habitats, which together occupy approximately 25 000 ha (37%) of the study area. Such studies include Turner (1976), Bowden and Turner (1976) and Floyd (1983).

One prominent theme in these studies has been the advance and retreat of the *Nothofagus moorei* dominated forests. Fraser & Vickery (1938) noted that *Nothofagus moorei* dominated forests were advancing into *Eucalyptus* spp. forests at all fronts, but that they lost ground to other rainforest types at lower altitudes. The latter observation was confirmed by Turner (1976) who noted that regeneration of *Nothofagus moorei* under the *Nothofagus moorei*-warm temperate rainforest ecotone did not occur. Floyd (1983) discussed these observations at some length with additional evidence of his own field studies of the existing vegetation. Although his studies showed that there is a clear and ongoing change of vegetation, with one-way boundary shifts of up to an estimated 500 years of age, Floyd was ambivalent about the longer term implications in the absence of further long term evidence.

Such long term evidence was provided for the vegetation on the plateaux several years later through several pollen analyses from the sub-alpine wetlands found on the plateaux. These include papers by Dodson et al. (1986), Dodson and Myers (1986), Dodson et al. (1994), and Sweller and Martin (1997). Results indicate that most present day vegetation communities have been present within the area for over 9000 years, although their relative proportions have changed considerably since then (Dodson et al. 1986). An expansion of wetlands as well as forests dominated by *Nothofagus moorei* (particularly towards the north-west), which commenced approximately 6000 BP is thought to be due to an increase in rainfall and possibly temperature (Dodson et al. 1986, Sweller & Martin 1997).

The State Forest Commission of NSW (now State Forests of NSW) has previously mapped the dominant species (and some structural information) of the canopy vegetation of large parts of the study area. This mapping is known as the 'Royal Milli Forestry Maps', and a compilation of this mapping ('Royal Milli Vegetation Management Mapping') was prepared for the NPWS by McKimmie Jamieson & Partners (Aust.) Pty Ltd (1985).

A floristic analysis of the State Forests of the area, parts of which are now included within the National Park boundaries, is provided by Binns (1995).

Fire responses and the National Plant Fire Response Register

Knowledge of the vegetation response to fire can be employed to determine appropriate fire regimes for the maintenance of the current species composition and structure or to cause a shift in these characteristics, optionally to a predetermined goal.

As fire is an important and often recurring factor in many Australian ecosystems, considerable research has been conducted to qualify and quantify responses within individual species and within vegetation types (e.g. Gill & Bradstock 1992, Bradstock et al. 1995, DEST 1996). The application of this research to the management of the current study area is two-fold:

- To manage different types of vegetation;
- To manage individual species, such as significant species.

The response of vegetation to fire can be described in several ways (Gill & Bradstock 1992):

- Mechanistic descriptions, resulting in classifications of species with similar means of resistance and recovery, such as physical resistance properties of plants to fire (e.g. bark);
- Consequential descriptions, which are concerned with the end result of fire, such as survival or death;
- Strategic descriptions, which place importance on the evolutionary behaviour of species, such as whether plants are fire evaders, fire resisters, or fire endurers.

The National Plant Fire Response Register was established to provide information on each of these aspects of (Gill & Bradstock 1992). Information within the Register is sourced from the published literature, personal communications, personal observations and surveys. The 1997 version of the Register contained information on 2528 species, derived from 45 references. Fire response information is given in the form of 11 nominal categories. These are shown in Table 1.

Table 1. Codes for species' regenerative mechanisms (Source: Gill & Bradstock 1992).

Code	Mechanism
0	Unknown
1	100% scorch kills, regeneration from on-plant viable seed storage
2	100% scorch kills, regeneration from in-soil viable seed storage
3	100% scorch kills, no seed storage in burnt area
4	Survive 100% scorch, root suckers
5	Survive 100% scorch, basal sprouts
6	Survive 100% scorch, epicormics
7	Survive 100% scorch, outgrowth of large apical bud
8	1, 2, or 3 but which is unknown, and includes obligate seed regeneration of McMahon (1987)
9	4, 5, 6, or 7 but which is unknown, and includes facultative resprouters of McMahon (1987)
10	Ferns
11	Obligate resprouters of McMahon (1987)

Those species which are killed by fires and which rely on seed (in seed banks, on plant, or import of propagules from outside the burnt area) would be favoured if fires were sufficiently intense to also kill competing plants which rely primarily on their resprouting capacity for post-fire recovery (Adams & Simmons 1996). In contrast, if fires were relatively cool but frequent, seeders would be disadvantaged, as fragile seeder plant seedlings are destroyed before they can set seed.

Knowledge of the fire response of species which comprise a vegetation community can therefore be used to maintain, promote or suppress particular species or groups of species, and relatively simple deterministic fire regimes can be designed for individual species or small groups of similar species on this basis.

Problems arise when both resprouters and seeders are targeted for maintenance or promotion, as for example in a vegetation community largely consisting of resprouters, but also containing rare seeder plants and vice versa. There are also conflicts when the fire regime is based on requirements of overstorey species only, to the potential detriment of the understorey species (Keith & Bradstock 1994). In addition, desirable outcomes are also dependent on variables such as the size and shape of the area burned, unplanned fires, climatic and seasonal factors, the nature of the seedbank and soil in which it resides, interaction with non-target species, longevity of plants and propagules, age to maturity, fuel load, and regional differences in plant response mechanisms (e.g. Gill et al. 1981, Bradstock et al. 1995, DEST 1996). Data on many of these variables are lacking for most regions (Gill & Bradstock 1995), including the Barrington Tops region. Given the stochasticity of some of these variables (e.g. unplanned fires) it is also doubtful that data will ever be sufficient to design deterministic fire regimes suitable at the landscape scale over the long run.

In order to avoid some of these conflicts, and to precaution against errors made in determining fire intensities and intervals, a number of authors have emphasised the importance of fire regime variability in both space and time (Fox 1983, Lamont et al. 1993, Bradstock et al. 1995, Gill 1996). Bradstock et al. (1995) proposed the concept of a threshold level above which fire regime variability is sufficiently high to conserve full diversity (prevent the extinction of species) and below which diversity declines through fire regime uniformity. Using a model, Keith and Bradstock (1994) provided an example of how the threshold concept can be applied to a heath mosaic in the Royal National Park in which species were classified into a small number of functional groups. Input information used included the types of propagules, post-fire growth, reproductive timing, reproductive mechanism, and the competitive status.

Clearly, much of this information is not available for the vegetation of the Barrington Tops area at this stage. A considerable amount of monitoring will be required in order to generate the data required to develop models such as that by Keith and Bradstock (1994).

The emphasis of the present paper is, therefore, on the provision of floristic information, which, once further information on parameters such as those used by Keith and Bradstock (1994) becomes available, can be used to develop scientific fire regimes and relatively detailed strategies at a later stage. Nevertheless, it is considered that current information available on the regenerative mechanisms could be used as a rudimentary guide to the formulation of interim fire management strategies, using the principles as outlined above. Monitoring should be an integral part of fire management strategy (Gill & Nicholls 1989), and, hence, guidelines for the establishment of a monitoring program are also provided.

Methods

Data sources and quality

Data on the vegetation of the study area were obtained from a variety of sources and includes plot data from within and surrounding the study area. Most data originate from plots used for the Flora Survey component (Binns 1995) of the Gloucester and Chichester Management Areas Environmental Impact Statement (EIS) (SFNSW 1995). Most of these plots were surveyed in 1991–1992 specifically for the preparation of the EIS (Binns 1995). However, a number of plots were surveyed in 1987–1989 (Binns, unpublished data), and several of these occur within the Whispering Gully part of the present study area.

Plot data from Mount Royal National Park and adjacent areas originate from such sources as the Comprehensive Resource Assessment surveys (post 1995), the North-East Biodiversity Study (1992–1993), but also includes data from older sources, possibly as old as the 1960s (P. Lezaich, State Forests NSW, pers. comm.).

A survey of a further 51 plots within the study area was commissioned by the NPWS specifically for the present project (Horton & Hunter, unpublished data). These plots are mostly located in the central and south-eastern parts of the Barrington Tops National Park.

All data was supplied by NPWS Northern Zone Office. The total number of plots used in the analyses for this project was 262, of which 154 plots were located within the boundaries of the National Parks.

Information obtained from each plot included a list of plant species present and their abundances as expressed in a code based on a modified Braun-Blanquet scale for cover (Table 2).

Table 2. Modified Braun-Blanquet scale for plant species' canopy cover.

Cover Code	Projected Canopy Cover
1	< 5%, few individuals
2	< 5%, any number of individuals
3	6–25%
4	26–50%
5	51–75%
6	75–100%

The availability and consistency of other information, such as structural and environmental data, varied considerably from plot to plot. Some of these data were estimates that may differ from observer to observer. This data was, therefore, sometimes of limited use in the analysis for the present project. Nevertheless, even though some estimates may have been somewhat coarse, data utilised for analyses included data on estimated severity and frequency of fires and past logging, altitude, aspect, slope, landform element, morphology, soil group, and soil depth. Such data was available for 15–120 plots, depending on the variable.

Other environmental information used include data from the NPWS Coffs Harbour Northern Zone office GIS system. This information includes data on climate, terrain, and geology. Data for these variables was available for all plots.

Lists of rare and threatened species and exotic species were obtained from the NPWS Coffs Harbour Northern Zone office. Plant responses to fire were sourced from the National Plant Fire-Response Register held by the Malcolm Gill (CSIRO).

Analysis

Floristic data were analysed using a number of routines provided within the PATN computer package (Belbin 1993). In order to restore the approximate cover ratios encountered in the field, the cover codes supplied in the original data were transformed to the midpoints of the percentage cover intervals represented by the codes, except for code intervals 1 and 2, which were transformed to 1% and 3%, respectively.

Information on the structural characteristics of the vegetation was patchy, preventing the differential weighting of canopy species and understorey species. All species were therefore treated equally within the analyses. Although this introduces distortions with respect to the reflection of the ecological significance of species found in different vegetation strata within the covariance matrix (see below), it should be noted that the emphasis of the current project is on the understorey vegetation of the study area, as this is the vegetation stratum which is of greatest significance for fire management. The dominant influence of the species rich lower strata within the analyses applied is therefore justified.

Data of many environmental variables were originally in a nominal (non-numerical) format. For example, 'values' for variables such as morphology and geology included 'tertiary basalt' and 'hill slope'. Because most of the analyses conducted require ratio type data, nominal variables were converted to binary (presence-absence) variables, resulting in one extra variable for each nominal value. A total number of 54 environmental variables were thus used in the analysis. These are listed in Table 3.

A similar treatment was conducted for data obtained from the National Plant Fire Response Register. As the register is based on 45 literature references from different authors, species are frequently listed with a number of fire response mechanisms, as different authors have observed different mechanisms. To facilitate analysis and data management, only the first (often the only) mechanism observed was used.

Table 3. Environmental variables used in the analysis.

GIS variables

Description	**Type**
Longitude (AMG)	Ratio
Latitude (AMG)	Ratio
Minimum temperature at the coldest month (°C ×10)	Ratio
Mean annual temperature (°C ×10)	Ratio
Solar radiation (MJm^{-2} day^{-1})	Ratio
Soil fertility (from soil landscape maps, geochemical data modelling)	Interval
Slope (degrees)	Ratio
Soil depth (mm)	Ratio
Mean annual rainfall (mm)	Ratio
Wetness or compound topographic index (derived from terrain variables)	Ratio
Skidmore topographic position — mean difference in elevation	Ratio
Ruggedness index (250 m window)	Ratio
Ruggedness index (500 m window)	Ratio
Ruggedness index (1000 m window)	Ratio
Topographic index (250 m window)	Ratio
Topographic index (500 m window)	Ratio
Topographic index (1000 m window)	Ratio
NEFBS moisture index (from other GIS information)	Ratio
Rainfall in the driest quarter of the year (mm)	Ratio
DLWC geology map units	Nominal
Basic igneous	Binary
Acidic volcanic	Binary
Granite	Binary
Sedimentary rocks (high quartz)	Binary
Sedimentary rocks (low quartz)	Binary

Plot variables

Description	**Type**
Field estimate of previous fire severity (0–3)	Interval
Estimate or record of years since last fire	Ratio
Altitude (m)	Ratio
Slope (degrees)	Ratio
Aspect (degrees)	Ratio
Landform Element	Nominal
Bench	Binary
Drainage depression	Binary
Foot slope	Binary
Gully	Binary
Hill crest	Binary
Hill slope	Binary
Scarp	Binary
Stream channel	Binary
Swamp	Binary
Valley flat	Binary

Morphology	Nominal
Crest	Binary
Closed depression	Binary
Flat	Binary
Lower slope	Binary
Mid-slope	Binary
Simple slope	Binary
Upper slope	Binary
Open depression	Binary
Soil Type	Nominal
Clay	Binary
Loam	Binary
Sand	Binary
Organic	Binary
Soil depth (in three classes)	Interval
Field estimate of previous logging severity (0–3)	Interval
Estimate or record of years since last logging	Ratio
Field estimate of previous grazing severity (0–3)	Interval
Estimate or record of years since last grazing	Ratio

While this may have introduced some bias, most mechanisms listed for a species were closely related. In order to cancel out some bias, related mechanisms were also amalgamated into two contrasting groups, including one group with species relying on seed regeneration, and another with species relying more on resprouting. All regenerative mechanisms were converted to binary variables

In this paper, it is assumed that species with higher abundance require greater emphasis than less abundant species when the objective is to maintain the species composition of vegetation. 'Present' values (i.e. '1') were, therefore, subsequently weighted by the transformed percentage cover data for each matching species to increase the importance of abundant species. Only native species were used for the fire response analyses.

Gross variables were created by amalgamating all seeder mechanisms and all resprouter mechanisms into two contrasting groups, including one group ('Seeder') with mechanisms 1, 2, 3, and 8, and the other ('Resprouter') with mechanisms 4, 5, 6, 7, 9 and 11 (see Table 1). Mechanism 10 ('Ferns') was not reclassified in this manner, as the affinity of this group of plant for either of the two gross variables is not clear or varies. To eliminate the effect of different species numbers among sites and vegetation communities, a variable 'Resprouter:Seeder' was created by dividing the number of species with the 'Seeder' variable with the number of species with the 'Resprouter' variable. Missing data were coded as -9999.

The Bray and Curtis dissimilarity measure was used as a measure of the differences between the floristic composition of the plots. It has consistently performed well in a variety of tests and simulations on different types of data (Faith et al.1987). The plots were classified using the flexible unweighted pair-groups method using arithmetic averages (UPGMA) (a hierarchical agglomorative procedure), with a default beta value of -0.1. The number of vegetation communities to be used for subsequent mapping and further analysis was initially determined by taking the root of the total number of plots used for the analysis, thus resulting in 16 communities. However, detailed examination of the 16 communities indicated that two of these communities were not meaningfully different from adjacent communities (Binns, pers. comm.), hence the final group definition level chosen was 14.

A non-parametric one-way Analysis of Variance (ANOVA) was used to determine the importance of individual species, environmental variables, and fire response mechanisms in discriminating between the vegetation communities. The technique yields the Kruskal-Wallis statistic. Within any data set, variables with higher Kruskal-Wallis value are more significant that those with lower values.

The plots were also ordinated, using the detrended correspondence analysis technique (DCA) (Hill & Gauch 1980). This technique allocates most of the variation within the data set into the first dimension, with less variation in each subsequent dimension. Environmental and fire response variables were correlated to the first four (most important) dimensions of the ordination space using the principal axis correlation facility provided in PATN. The significance level of the correlation was approximated with Monte Carlo methods.

Results

Species recorded

A total of 890 species (including 66 species identified to genus level only) were found within the 262 plots, representing a total of 11 538 records. Records do not include plant species found outside the plots. The total number of species is therefore likely to be an underestimate of the true number of species present. In addition, plants such as members of the Orchidaceae and Liliaceae may have been overlooked during plot surveys if surveys were conducted outside growing seasons, further reducing the proportion of plants sampled. Appendix A contains a listing for all species found.

Eight rare or threatened plant species were recorded in the plots surveyed for this project, in 60 records. Half the records (30) were from outside the National Park boundaries, including all records of *Grevillea granulifera*. Only seven species were recorded from within the Park boundaries. Several other rare or threatened plants are also known from the area, or have ranges which overlap the study area. Table 4 contains a list of species found within the area and their conservation status, based on Binns (1995), Heinrich and Dowling (1998) and R. Onfray (NPWS, pers. comm.).

An unusual record is that of *Eucalyptus macrorhyncha* found in some plots in the Stewarts Brook area. This species has not previously been encountered in the area. Samples have, however, been identified as belonging to *Eucalyptus macrorhyncha* by the herbarium of the Royal Botanic Gardens, though the features of the samples were somewhat atypical (Binns, pers. comm.).

Table 4. Rare or threatened plants within data set and their conservation status.

Species Name	Authority	ROTAP*	TSC
Acacia barringtonensis	Tind.	3RCa	
Asperula asthenes	Airy Shaw & Turrill	3VC-	Vulnerable
Chiloglottis palachila	D.L.Jones	3RC-	
Chiloglottis platyptera	D.L.Jones	2KC-	
Chiloglottis sp. aff. *pluricallata*			
Chiloglottis sphyrnoides	D.L.Jones	3KC-	
Chionogentias barringtonensis	L.G.Adams	2RC-	
Corybas sp. A		2RC-	
Cynanchum elegans	(Benth.) Domin	3ECi	
Diuris venosa	Rupp	2VC-	Vulnerable
Eucalyptus largeana	Blakely & Beuzev.	3R	
Euphrasia ciliolata	W.R.Barker	2KC-	
Galium curvihirtum	Ehrend. & McGillivray		
Grevillea granulifera	(McGillivray) R.Olde & N.Marriott	3KCa	
Hibbertia hermanniifolia	DC.	3RC-	
Leptospermum argenteum	J.Thompson	2RC-	
Leucopogon pilifer	Wakef.		
Marsdenia liisae	J.Williams	3 RC-	
Microtis sp. aff. *rara*	suggested by D.L.Jones		
Orthoceras strictum forma virile	suggested by D.L.Jones		
Ozothmanus sp. 1		2KC-t	
Phebalium sp.			
Plantago cladarophylla	B.G.Briggs, Carolin & Pulley	2RC-	
Plantago palustris	L.Fraser & Vick.	2RC-	
Plectranthus suaveolens	S.T.Blake	3KC-	
Pomaderris helianthemifolia	(Reisseck) Wakef.		
Prasophyllum rogersii	suggested by D.L.Jones		
Prasophyllum sp. A			
Prasophyllum sp. aff. *fuscum*	suggested by D.L.Jones		
Prasophyllum sp. aff. *odoratum*	suggested by D.L.Jones		
Pterostylis cucullata (sp. D)	R.Br.	3VCa	Vulnerable
Pterostylis elegans	suggested by D.L.Jones		
Pterostylis falcata (sp.C)	R.S.Rogers		
Pterostylis sp. aff. *cycnocephala*	suggested by D.L.Jones		
Pterostylis sp. aff. *parviflora*			
Senecio macranthus		3RC-	
Senna acclinis	(F.Muell.) Randell	3 RC-	
Tasmannia glaucifolia	J.Williams	3VCi	Vulnerable
Tasmannian purpurascens	(Vick.) A.C.Smith	2VC-t	Vulnerable

* 2: Restricted distribution in Australia (range < 100 km); 3: Range >100 km in Australia but in small, restricted populations;

E: Endangered; V: Vulnerable; R: Rare; K: Poorly known; C: Represented in national park or proclaimed reserve; a: adequately reserved; i: inadequately reserved; -: insufficient data; t: total known population reserved (see Briggs & Leigh 1995).

The incidence of exotic plants was generally low, with most species occurring at less than 5% cover at any plot where present. One exotic species with considerably stronger presence was *Cytisus scoparius*, which dominated the vegetation in some plots on the Barrington Tops plateau. It is one of the characteristic species of Vegetation Community 10, occurring around the edges of the sub-alpine wetlands (see Appendix B). It was introduced into the area in the 1840s, though it was not until the 1950's and 1960's that the species build up to nuisance levels (Waterhouse 1988). With the dedication of the southern end of the plateau as a National Park in 1969, seasonal cattle grazing and burning ceased, resulting in further expansion. By 1988, 10 000 ha were affected by *Cytisus scoparius*, with native undergrowth and overstorey species regrowth affected through shading by *Cytisus scoparius* (Waterhouse 1988). Since then the area affected has been successfully contained using chemical agents and some hand removal for control, though the density within the infestation increased (M. Schroeder pers. comm.).

In order to open up smaller areas known to be populated by rare or threatened plants, *Cytisus scoparius* is removed by hand. It is hoped that biological control agents, released since 1993, will be able to reduce the density across the larger infestation. However, considerable lead time will be required (up to 20 years) before these agents are anticipated to cause an impact (M. Schroeder pers. comm.). Further containment will therefore be necessary.

Another exotic species occurring in a much larger area than *Cytisus scoparius* is *Conyza albida*. It is common in the Mount Royal area as well as in the northern parts of the plateau, but generally occurs at relatively low quantities. No information is available on the history of this species within the study area. It is, however, unlikely that the species will develop into a problem weed, such as Broom, as it is typically a species of disturbed sites only. Most of the remaining exotic species are also typical of disturbed sites, and have a preference for moist conditions, such as gullies, riparian zones, and swamps.

Classification

As noted above, a total of 14 communities were delineated. An abbreviated dendrogram of the UPGMA classification showing the hierarchical arrangement of the 14 vegetation communities is shown in Fig. 2. Appendix B provides vegetation community profiles, detailing species with the highest fidelity (i.e. Kruskal-Wallis statistics), highest mean cover, and highest constancy. Tables 5 and 6 show the values and Kruskal-Wallis statistics respectively of the environmental characteristics of each community. The geographic distribution is shown in Fig. 3.

In brief, the results indicate that Community 1 to 6 represent *Eucalyptus* species dominated forest with species typical of the drier, lower slopes, with Community 3 and 5 at the wetter end of the spectrum and located primarily along clearly defined watercourses. Community 4 is a shrubby type vegetation (occasionally with trees), typical of rocky outcrops throughout the study area (Binns, pers. comm.), although some species found within the plots comprising this vegetation community occur only in areas adjacent to the National Park boundaries (e.g. *Grevillea granulifera* and *Eucalyptus macrorhyncha*).

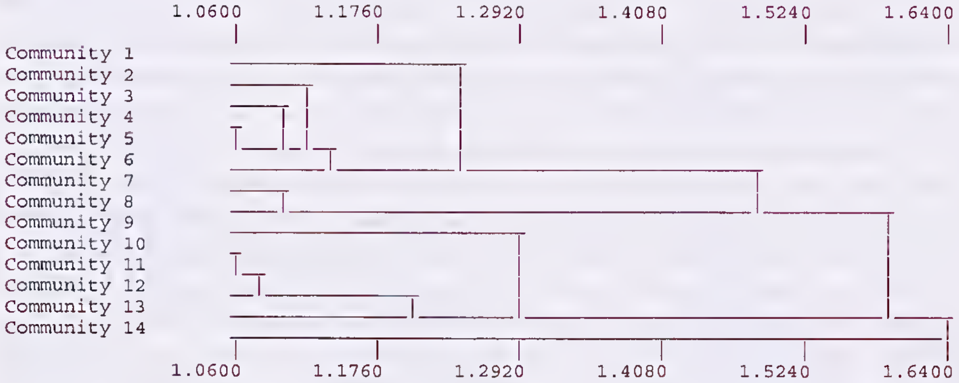

Fig. 2. Abbreviated dendrogram hierachical arrangement of vegetation communities. The relative dissimilarity values are shown alongside the dendrogram.

of 8.918, 6.181, 4.763, and 4.719. This indicates that there is at least one complete species turnover along each of these axes, with two turnovers in the first dimension. Thus, the species composition on the one end of the axis is completely different from that on the other end of the axis, with two such cycles in the first dimension (i.e. the first axis shows most of the variation).

Principal axis correlations for environmental variables are also listed in Table 6. Figs 4 and 5 show the vectors (standard length = 1) for variables with correlations over 0.5 and $p < 0.01$ in relation to the distribution of the plots in the first three dimensions of the species space.

Fig. 4 shows that the major floristic gradient (dimension 1) in the vegetation is from sub-alpine swamp (Community 12) and montane *Eucalyptus* spp. dominated vegetation types (Community 9 to 11) to rainforest (Community 7) and wet sclerophyll forest (Community 8). Another important gradient (dimension 2) is from the *Nothofagus moorei* dominated forests to the drier *Eucalyptus* spp. forests. Both floristic gradients appear to be related to changes in altitude, rainfall, temperature, and latitude, while time since last fire is particularly correlated with the second dimension.

The third floristic gradient is less clear but highlights the distinctiveness of some riparian vegetation types (Communities 5 and 11) at one extreme (Fig. 5). This pattern appears to be correlated to geology, soil fertility, and longitude.

Correlations with fire response mechanisms were weak but mostly significant (Table 8). The only mechanism which was insignificant was mechanism 11 (obligate resprouters). Only three mechanism had correlations over 0.5 ('resprouters', and mechanisms 4 and 5).

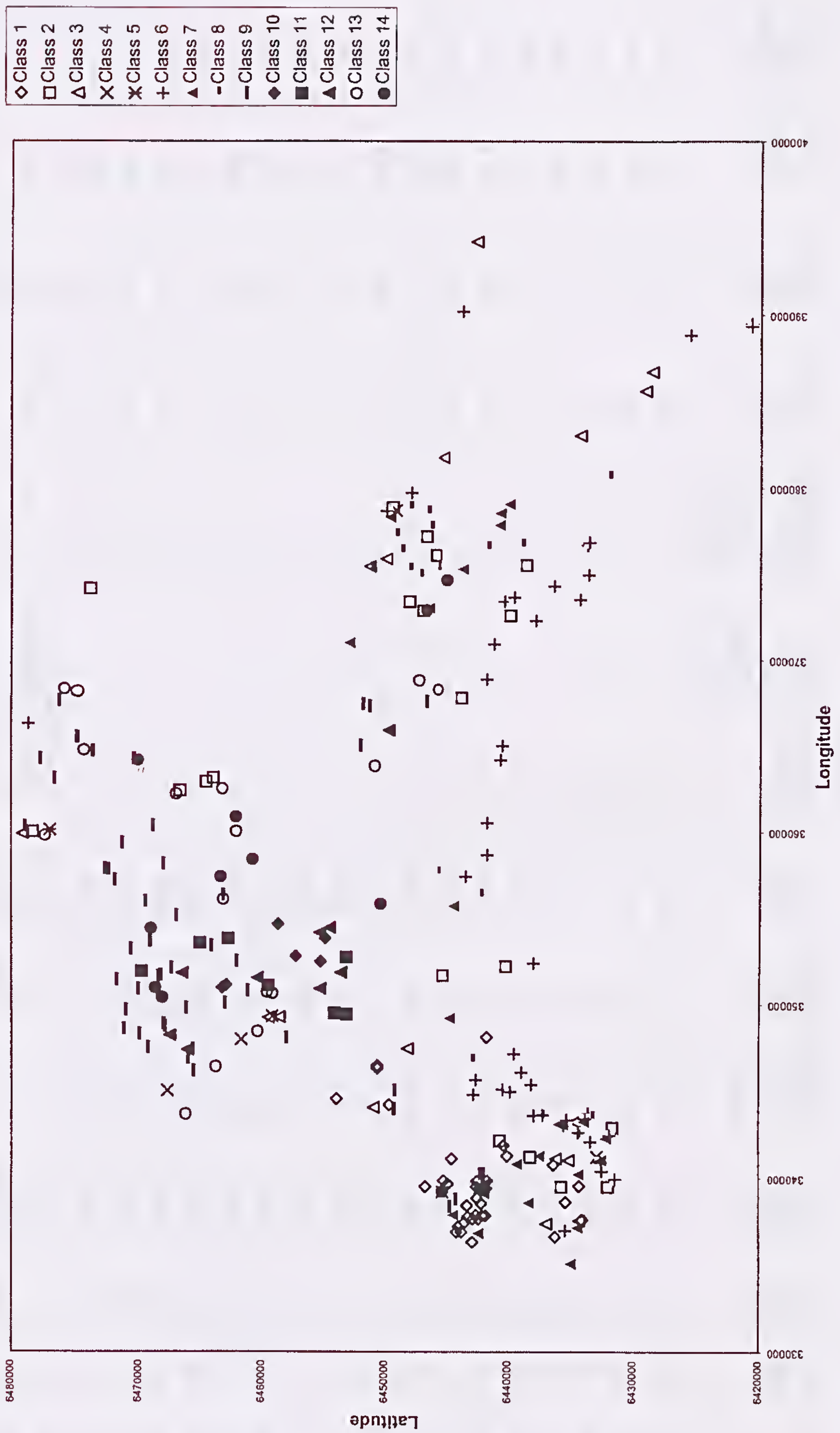

Fig. 3. Diagram showing the distribution of vegetation classes among plots in geographical space.

Table 5. Environmental values of vegeatation communities (the 15 variables with the highest Kruskal-Wallis values are shown only).

Community		Min. temp. (°C)	Mean temp. (°C)	Annual rainfall (mm)	Rainfall in driest quarter (mm)	Moisture index (mm)	Soil depth	Soil fertility	Basic igneous (index) (0=absent 1=present)	Low quartz sedimentary rock (0=absent 1=present)	Rugged-ness rock	Rugged-ness (250m)	Rugged-ness (500m)	Altitude (mm) (1000m)
1	Min.	-1.9	9.9	1172	228	81	959	2	0	0	9	17	35	850
	Max.	1.5	15.1	1852	396	94	1100	5	1	1	55	70	111	850
	Mean	-1.3	12.5	1415	291	90	1028	3.6	0.6	0.4	20.1	36	63.9	850
2	Min.	-2.1	11.6	1038	168	79	920	2	0	0	8	18	47	500
	Max.	2.1	15.2	1852	372	94	1070	5	1	1	41	63	118	1080
	Mean	-0.8	12.8	1415	291	90	1001	2.5	0.2	0.8	24.4	41.7	70.5	855
3	Min.	-2.2	12	1042	162	78	959	2	0	0	7	14	26	240
	Max.	5.8	17	1680	342	94	1139	5	1	1	39	72	121	760
	Mean	0.8	14.2	1343	241	87	1048	2.2	0.1	0.6	21.1	37.4	64.5	482
4	Min.	-1.3	11.2	1168	210	83	819	2	0	0	24	43	75	630
	Max.	1.3	14.9	1500	312	95	1009	2	0	1	41	77	134	1130
	Mean	-0.3	12.7	1376	266	89	952	2	0	0.4	31.6	51.4	91.2	880
5	Min.	-1.7	10.6	1300	270	93	970	2	0	0	8	15	29	-
	Max.	-0.6	12.1	1610	342	93	1080	4	1	1	37	70	105	-
	Mean	-1	11.3	1481	310	93	1040	3.3	0.7	0.3	20	38	70	-
6	Min.	-1.1	13.2	810	168	76	810	2	0	0	8	13	22	140
	Max.	5.6	17	1120	300	92	1120	2	0	1	61	70	94	600
	Mean	2.3	15.3	1023	218	85	1023	2	0	0.7	23.9	38.8	57.5	430
7	Min.	-1.9	12	1132	198	79	990	2	0	0	11	18	27	620
	Max.	3	15.9	1890	342	94	1129	5	1	1	31	57	113	870
	Mean	0.3	13.4	1388	250	88	1061	2.1	0.1	0.8	19.2	33.6	27.5	745

Community	temp. (°C)	Min. temp. (°C)	Mean rainfall (mm)	Annual driest quarter (mm)	Rainfall in index	Moisture depth (mm)	Soil fertility (index)	Soil igneous rock (0=absent 1=present)	Basic sedimentary rock (0=absent 1=present)	Low quartz (250m)	Ruggedness (500m)	Ruggedness (1000m)	Ruggedness (mm)	Altitude
8	Min.	-1.7	12	1156	180	81	970	2	0	0	9	14	23	400
	Max.	3.6	16.2	1872	324	93	1159	2	0	1	40	68	88	880
	Mean	3.2	14	1523	251	90	1044	2	0	0.9	24.3	41.2	63.9	675
9	Min.	-1.9	8.9	1104	222	82	939	1	0	0	1	3	8	840
	Max.	-0.6	12.8	2298	450	95	1179	5	1	1	38	55	96	1500
	Mean	-1	10.5	1565	325	93	1068	3	0.5	0.2	13.2	23.5	39.6	1258
10	Min.	-1.7	9	1844	390	94	1110	4	0	0	2	2	6	1430
	Max.	-1.3	9.4	2248	468	95	1220	4	1	0	8	16	29	1500
	Mean	-1.5	9.2	2087	440	95	1171	4	0.7	0	5.8	9.8	16.8	1452
11	Min.	-1.7	8.9	1438	306	94	1019	4	0	0	4	10	16	1310
	Max.	-1.1	9.9	2336	486	95	1190	4	1	0	16	25	68	1540
	Mean	-1.4	9.3	1983	418	94.7	1128	4	0.9	0	8	16.1	32.3	1463
12	Min.	-1.6	9	1432	312	93	1049	2	0	0	2	7	17	1200
	Max.	-0.7	10.6	2292	480	95	1190	4	1	0	12	22	24	1460
	Mean	-1.2	9.7	1959	411	95	1143	3.6	0.6	0	5.8	12.1	21.1	1377
13	Min.	-1.7	10	1238	246	91	970	2	0	0	4	10	24	1000
	Max.	-0.6	12.1	2336	468	95	1220	4	1	1	39	63	116	1380
	Mean	-0.9	11	1618	325	93	1063	2.7	0.2	0.6	20.5	35.3	61	1273
14	Min.	-1.3	9.5	1462	312	93	990	2	0	0	7	13	21	1040
	Max.	-0.6	11.8	2280	468	95	1120	4	1	1	40	69	104	1380
	Mean	-1	10.4	1761	356	94	1069	3.3	0.5	0.4	19.3	33.9	59.1	1273

Table 6. Principal axis correlations and Kruskal-Wallis statistics for environmental variables.

Variables	**Correlation Coefficient (p)**	**Kruskal-Wallis statistic (p)**
GIS variables		
Acidic volcanic	0.1256 N.S.	12.79 N.S.
Basic Igneous	0.5312 **	85.75 **
Granite	0.4172 **	53.34 **
Sedimentary rocks (high quartz)	0.3061 **	30.96 **
Sedimentary rocks (low quartz)	0.5513 **	83.43 **
Latitude	0.7455 **	151.85 **
Longitude	0.5635 **	80.86 **
Mean annual rainfall	0.5884 **	83.63 **
Mean annual temperature	0.8965 **	207.45 **
Minimum temperature at the coldest month	0.6135 **	110.43 **
NEFBS moisture index	0.7036 **	154.26 **
Rainfall in the driest quarter of the year	0.7704 **	149.33 **
Wetness index	0.2789 **	52.53 **
Solar radiation	0.3832 **	56.89 **
Ruggedness index (1000 m window)	0.3655 **	84.66 **
Ruggedness index (250 m window)	0.4353 **	91.01 **
Ruggedness index (500 m window)	0.4173 **	89.2 **
Skidmore topographic position	0.1522 N.S.	34.34 **
Slope	0.3809 **	73.86 **
Soil depth	0.3822 **	77.41 **
Soil fertility	0.5342 **	91.38 **
Topographic index (1000 m window)	0.2300 **	54.7 **
Topographic index (250 m window)	0.3229 **	19.13 N.S.
Topographic index (500 m window)	0.2844 **	35.11 **
Plot Variables		
Altitude	0.9273 **	92.90 **
Slope	0.4237 **	36.33 **
North facing	0.1158 N.S.	5.98 N.S.
North-east facing	0.2316 N.S.	12.18 N.S.
East facing	0.3562 **	10.61 N.S.
South-east facing	0.0759 N.S.	12.91 N.S.
South facing	0.2420 N.S.	15.86 N.S.
South-west facing	0.1021 N.S.	5.89 N.S.
West facing	0.2342 N.S.	10.42 N.S.
North-west facing	0.1287 N.S.	8.07 N.S.
Field estimate of previous fire severity	0.4291 *	23.07 *
Estimate or record of years since last fire	0.5617 **	33.37 **
Field estimate of previous grazing severity	0.3740 N.S.	14.79 N.S.
Estimate or record of years since last grazing	0.4510 N.S.	7.31 N.S.
Field estimate of previous logging severity	0.3740 N.S.	22.08 *
Estimate or record of time since last logging	0.6205 *	11.14 N.S.
Soil depth	0.2523 N.S.	20.39 N.S.

Variables	**Correlation Coefficient (p)**	**Kruskal-Wallis statistic (p)**
Clay	0.1368 N.S.	11.94 N.S.
Loam	0.1605 N.S.	16.94 N.S.
Sand	0.3969 **	28.22 **
Organic soil	0.2842 N.S.	20.24 N.S.
Crest	0.1567 N.S.	16.38 N.S.
Upper slope	0.1154 N.S.	12.13 N.S.
Mid-slope	0.1826 N.S.	15.00 N.S.
Lower slope	0.1924 N.S.	10.94 N.S.
Simple slope	0.3327 *	22.34 *
Flat	0.1940 N.S.	13.25 N.S.
Open depression	0.1449 N.S.	34.15 *
Closed depression	0.1213 N.S.	6.51 N.S.
Hill crest	0.1631 N.S.	16.44 N.S.
Hill slope	0.2701 N.S.	21.85 *
Bench	0.1438 N.S.	8.93 N.S.
Scarp	0.1227 N.S.	6.83 N.S.
Stream channel	0.1716 N.S.	13.25 N.S.
Swamp	0.2067 N.S.	13.25 N.S.
Valley flat	0.1940 N.S.	13.25 N.S.
Drainage depression	0.2072 N.S.	13.25 N.S.
Gully	0.2788 *	18.00 N.S.
Foot slope	0.1886 N.S.	4.72 N.S.

N.S. = $p > 0.05$; * = $p < 0.05$; ** = $p < 0.01$

Community 7 and 8 represent plots in the moister environments on the lower slopes with rainforest (without *Eucalyptus* spp.) and wet sclerophyll (with *Eucalyptus* spp.), respectively.

Community 9 to 13 consist of plots with montane and sub-alpine *Eucalyptus* spp. forest and woodland as well as wetland vegetation typical of the plateaux.

Community 14 consists of *Nothofagus moorei* dominated vegetation, and is primarily located on the sheltered escarpment slopes on the edge of the plateaux as well as in sheltered locations on the plateaux.

Table 7 lists the average number of species per vegetation community for each fire response mechanism. The total number of native species records matching with a known fire response from the National Fire Response Register was 5364. As the total number of plant records was 11 538, not all species found within the study area are therefore accounted for in the averages. Nevertheless, Kruskal-Wallis statistics were significant at $p < 0.01$ for all response mechanisms (Table 8).

Ordination

The DCA ordination of plots resulted in eigen values of 0.7979, 0.6558, 0.4155, and 0.3743 for the first four dimensions respectively, with corresponding gradient lengths

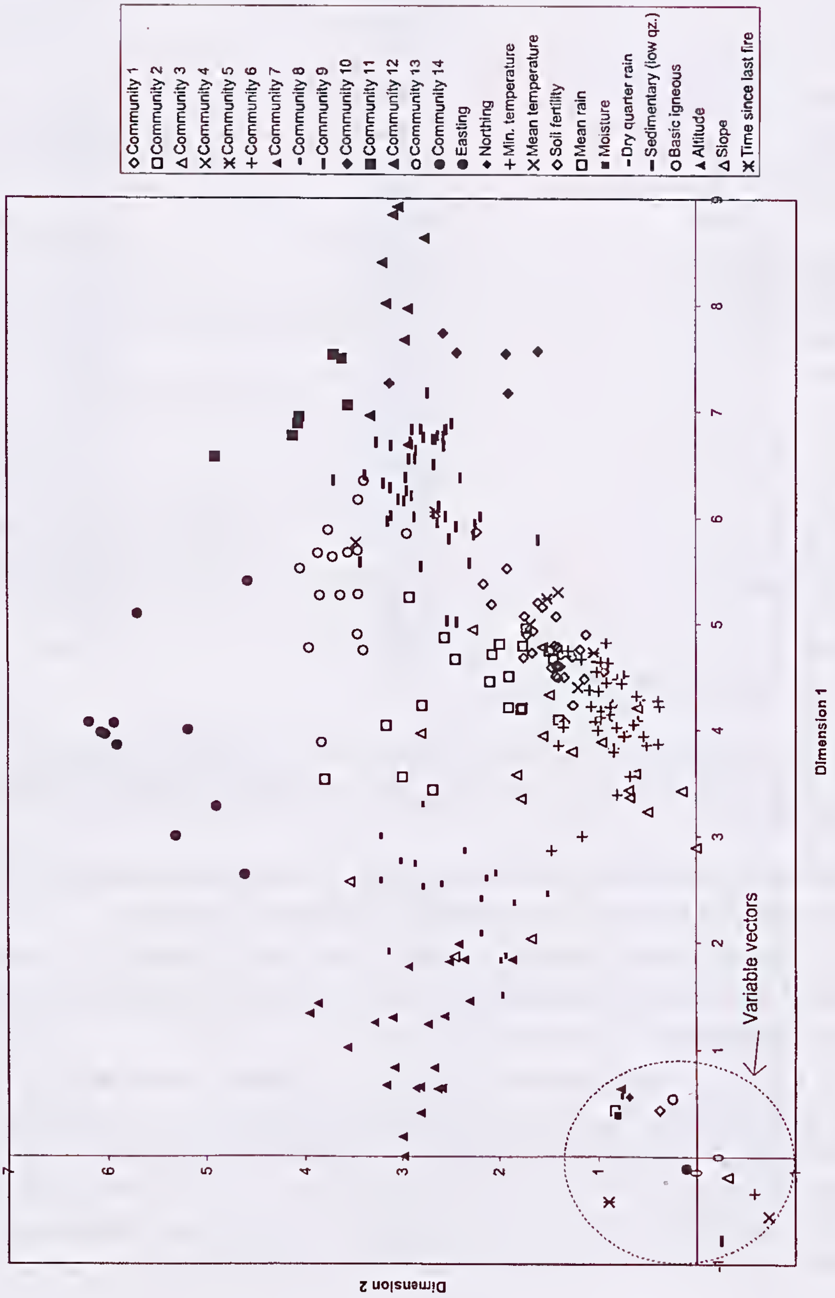

Fig. 4. Ordination of Plots (Dimensions 1 and 2).

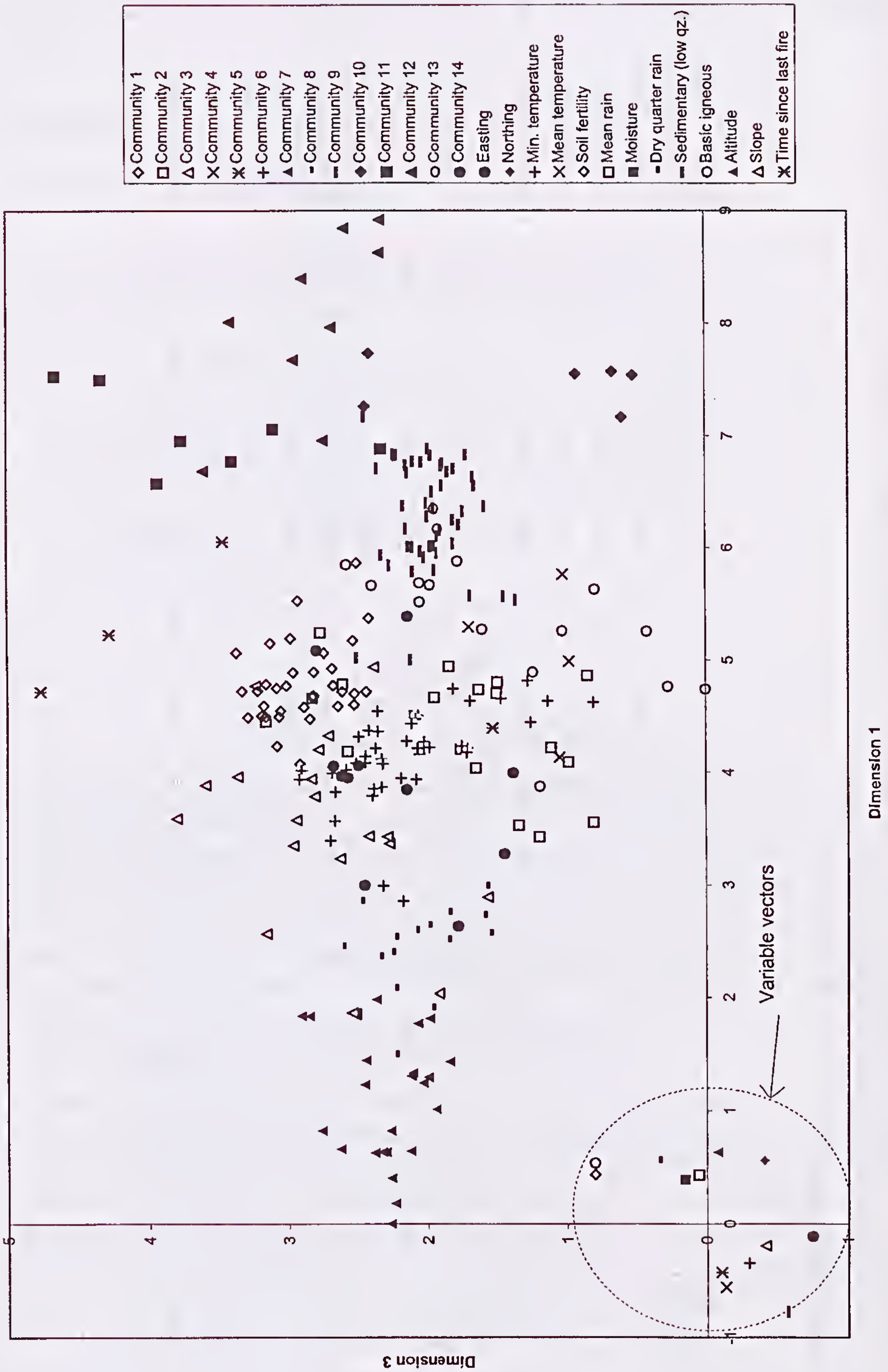

Fig. 5. Ordination of Plots (Dimensions 1 and 3).

Table 7. Average number of species per vegetation community for each plant fire response mechanism (S = Seeder; R = Resprouter; R:S ratio = Resprouter: Seeder ratio; K:U ratio = Known:Unknown fire response ratio).

Response Mechanism

Community	Av. no. species	1	2	3	4	5	6	7	8	9	10	11	S*	R* ratio	R:S	K:U ratio
1	47.03	0.00	3.00	0.06	2.50	1.44	0.74	0.00	8.56	4.32	2.03	0.94	11.62	9.94	0.86	0.46
2	37.95	0.15	3.65	0.00	2.10	1.65	0.95	0.05	4.90	3.70	1.90	1.10	8.70	9.55	1.10	0.48
3	56.53	0.05	2.89	0.00	2.21	1.37	1.16	0.05	7.47	5.05	2.79	1.47	10.42	11.32	1.09	0.38
4	28.80	0.20	1.60	0.00	2.60	1.20	0.40	0.00	4.20	2.40	0.00	2.20	6.00	8.80	1.47	0.51
5	35.00	0.33	0.67	0.00	1.67	0.00	0.33	0.00	4.67	1.33	1.67	0.67	5.67	4.00	0.71	0.28
6	51.84	0.00	3.79	0.07	3.02	2.60	0.95	0.05	5.95	4.51	1.70	1.40	9.81	12.53	1.28	0.43
7	51.04	0.00	0.91	0.00	0.17	1.30	0.74	0.17	4.13	2.09	3.57	0.35	5.04	4.83	0.96	0.19
8	49.22	0.11	1.39	0.00	0.50	1.61	1.00	0.39	3.72	3.06	2.67	1.22	5.22	7.78	1.49	0.26
9	42.77	0.17	3.38	0.29	1.79	0.79	0.73	0.00	7.92	4.48	1.46	1.29	11.75	9.08	0.77	0.49
10	26.83	0.00	1.33	0.33	0.50	0.17	0.50	0.00	1.67	2.17	0.17	0.17	3.33	3.50	1.05	0.25
11	35.57	0.00	2.00	0.14	1.14	0.29	1.00	0.00	5.29	2.86	1.86	1.14	7.43	6.43	0.87	0.39
12	32.00	0.00	2.00	0.11	0.78	0.33	0.89	0.00	3.44	2.44	0.67	0.22	5.56	4.67	0.84	0.32
13	35.88	0.44	2.69	0.00	1.69	0.56	1.31	0.00	6.06	3.19	2.63	1.94	9.19	8.69	0.95	0.50
14	22.09	0.09	0.64	0.00	0.55	0.00	0.36	0.00	3.09	2.09	2.36	1.09	3.82	4.09	1.07	0.36

Table 8. Principal axis correlations and Kruskal-Wallis statistics for plant fire response mechanisms.

Fire Response Mechanism	Correlation Coefficient (p)	Kruskal-Wallis statistic (p)
Resprouter	0.5202 **	121.28 **
Seeder	0.4344 **	123.33 **
Resprouter:Seeder	0.3387 **	59.88 **
1	0.2745 **	43.12 **
2	0.3944 **	100.09 **
3	0.3354 **	42.17 **
4	0.5932 **	152.32 **
5	0.6291 **	112.74 **
6	0.1995 *	46.68 **
7	0.2372 **	51.67 **
8	0.3922 **	104 **
9	0.3634 **	97.73 **
10	0.4540 **	73.21 **
11	0.1199 N.S.	67.24 **

N.S. = $p > 0.05$; * = $p < 0.05$; ** = $p < 0.01$

Discussion

Environmental relationships

The principal axis correlations for environmental variables suggest that the overall (linear) floristic pattern is most strongly related to topographic, geographic, edaphic, and, particularly, climatic variables. 'Years Since Logging' and 'Years Since Last Fire' were also relatively highly correlated, but it should be recognised that much of this data is based on subjective field estimates, often several years after a fire had occurred. The number of sites for which this data was available was also relatively low, with 95 sites available for 'Years Since Last Fire' and only 29 for 'Years Since Last Logging'. Several other environmental variables also had significant correlations (including 'Fire Severity'), but the relationships were weak (correlation < 0.5).

Those variables with significant correlations generally also had significant Kruskal-Wallis statistics. While rank order broadly corresponds (e.g. the six variables with the highest correlations also had the highest Kruskal-Wallis statistics), differences in the rank order may be related to differences in the linearity of variables. For example, while altitude had the highest correlation, its Kruskal-Wallis value was only sixth highest. Mean annual temperature, on the other hand, had the second highest correlation and the highest Kruskal-Wallis statistic, possibly reflecting the influence of air inversion in depressions, whether at high or at low altitudes.

The significant correlations and Kruskal-Wallis statistics for 'Years Since Last Fire' and 'Fire Severity' suggest that the vegetation composition of the study area is related to the incidence of fire, at least within the timeframe of the existing observations and records (maximum 70 years). C. Howard (pers.comm.) comments that major fire events in the late 1950's and early 1960's burnt substantial areas of the Barrington Tops National Park. In addition, sections of the boundaries of the National Park have been subject to regular fires (3–10 year intervals) over the last 100 years which have entered the forests from adjoining grazing lands.

Palaeological studies conducted in the area, however, indicate that the longer term effects of fire are less clear. Dodson (1986), in a study of pollen analyses from eight sites and 57 radiocarbon analyses from nine sites across the Barrington Tops plateau, found that, although the incidence and/or intensity of fires increased from low levels around 3000 BP, 'no major vegetation shifts could be directly attributed to fire'. Similarly, in a palaeological study of Burraga Swamp, south-west of Mt Lumeah, Dodson (1994) found that 'there are no close relationships between charcoal and tree pollen abundance providing some indication that fire has been of minor significance in forest tree dynamics during the last 2000 years'. Any changes that have occurred at Burraga Swamp were instead attributed to logging activities within the catchment and to increased use of the area by day trippers.

Dodson and Myers (1986), among others, showed that Australian pollen types travel in quantity only a few tens of metres. Swamp sediments are therefore likely to record predominantly local fire history of the vegetation. However, the similarity of results from several swamps across the plateaux suggests that the pattern was widespread, a least on the plateaux. This would be despite extensive grazing by cattle and associated burning of the plateau prior to becoming part of the National Park.

Whether the situation is similar at lower altitudes is uncertain in the absence of further palaeological data from those environments. Although fire is obviously a prominent feature, it is, however, not clear that fire has had an influence on the long term composition and layout of the vegetation mosaic within the study area.

Fire response mechanisms

As noted above, correlation coefficients and Kruskal-Wallis statistics were significant for all fire response mechanisms, except for mechanism 11 (insignificant correlation only) (Table 8). High values were obtained particularly for mechanisms 4 (survive a 100% scorch, regenerate through root suckers) and 5 (survive a 100% scorch, regenerate through basal resprouting) and for the two composite mechanisms 'Resprouter' and 'Seeder'.

As shown in Table 7, mechanisms 4 and 5 are particularly prevalent in Vegetation Community 6 (characterised by *Eucalyptus saligna*, *Eucalyptus acmenoides*, *Eucalyptus canaliculata*, *Poa labillardieri*, and *Imperata cylindrica*, located in an arch along the southern boundary of the study area — Fig. 3). However, high 'Resprouter' and 'Seeder' values often occur in the same communities (e.g. Communities 1, 2, 3, 6, 9 and 13). This is not a reflection of the importance of either mechanism, but more related to the higher number of species' matches with the listings of the National Plant Fire Response Register within these vegetation communities, which itself is a function of the average number of species recorded per community (Table 7). Clearly, the larger the number of species recorded, or the number of species' matches with the Register, the higher the average for the fire response mechanisms. In order to neutralise this bias, the 'Resprouter:Seeder' variable was calculated, which had both a significant correlation coefficient and a significant Kruskal-Wallis statistic (Table 8).

Vegetation communities with particularly low 'Resprouter:Seeder' values include Vegetation Communities 5 and 9 (Table 7). The lower values would indicate that, in general, the maintenance of these vegetation communities requires occasional high intensity fires to maintain the predominance of 'Seeders' over 'Resprouters', as only such fires can damage 'Resprouters' sufficiently to diminish their competitive advantage after a fire (see e.g. Adams & Simmons 1996). In order to develop the fuel load required for hot fires, such fires can only be applied infrequently. A similar strategy could be used to develop a predominance of 'Seeders' over 'Resprouters' in vegetation which does not already contain a predominance of 'Seeders'.

Unfortunately, there are no hard data are available to base the approximately length of the fire intervals. As noted above, there are some data on time interval since last fire and intensity for some plots, but these are largely based on field estimates. In addition, there are no data on fire frequencies for larger areas or longer periods of time. However, based on personal experience, local fire management officers consider a period of 12–20 years to be appropriate for areas away from the rainforest (R.Onfray pers.comm.).

In order to maintain or develop the predominance of 'Resprouters' in vegetation communities with high 'Resprouter:Seeder' values (such as Communities 4 and 8), low intensity fires are prescribed. 'Resprouters' quickly regenerate after such fires, providing heavy competition for 'Seeders'. Local fire management officers consider a period of 5–12 years to be appropriate (R. Onfray pers.comm.).

Low intensity fires are particularly effective in this way if often repeated, resulting in a depletion of the soil seed bank. Effectiveness is also enhanced if the low intensity fire is followed by a drought, resulting in the wilting of any seedlings which manage to establish after fire. In the study area, dry periods are common during late autumn and spring (see above). Thus, a low intensity fire during early autumn/late summer or early spring/late winter would be particularly effective in maintaining or effecting a 'Resprouter' dominated community within the study area.

Vegetation communities with intermediate 'Resprouter:Seeder' values could be maintained or developed using intermediate fire regimes. Thus, a moderate fire in autumn/summer would favour 'Seeders' slightly, relative to low intensity fires, while a moderate fire in spring (followed by the main growing season) would increase this trend.

With any of the above strategies, variability in both space and time would required to minimise the risk of extinction of species with differing requirements (e.g. Bradstock et al. 1995). For example, even in Communities 5 and 9, with very low Resprouter: Seeder ratios, there is still a considerable proportion of plants relying on their ability to resprout as a regeneration mechanism. Furthermore, some of these species may be rare or threatened and their requirements may, therefore, have precedence over those of other species. So far, only one threatened species occurring in the Barrington Tops area *(Acacia barringtonensis)* appears in the National Plant Fire Response Register. Further research is required to confirm the fire response mechanisms for the other species.

The analysis above can be used as a preliminary framework to determine suitable monitoring points for the experimental establishment of appropriate fire regimes. For example, to determine the effect of different fire regimes (frequencies, timing, intensities) on communities dominated by 'Seeders', monitoring points should be established in locations covered by Vegetation Communities 1, 5, 7, 9, 11, or 14. To determine the effect of different regimes on 'Resprouter' dominated communities, monitoring points should be established in Vegetation Communities 4, 8, and 10. Suitable fire regimes for Vegetation Communities with intermediate 'Resprouter:Seeder' values may than be interpolated from the results.

It should be born in mind that the Kruskal-Wallis statistic and the correlation coefficient of the 'Resprouter:Seeder' variable were relatively low (though significant). The framework outlined in the previous paragraphs is therefore preliminary, and its reliability would benefit from further information on response mechanisms of those species for which these mechanisms are presently unknown. In the absence of such knowledge it may therefore be wiser to establish a number of monitoring points in each of the delineated vegetation communities, with a variety of fire regimes applied in each vegetation community. Apart from monitoring fire characteristics and their effect on the vegetation, such plots could also be used to monitor the build up of fuel loads, for example using litter traps. The rate of fuel load build-up would provide, however, only one of a number of indications (as outlined above) required to establish an appropriate fire regime.

When monitoring, care should be taken to determine the age before seeding of 'Seeder' species. In order to maintain the presence of 'Seeder' species, fires should be avoided before seeding has occurred. Thus, those species requiring the longest period for setting seed are those species which determine the minimum time interval between fires.

Limitations

The study has been limited by a number of factors. The implications of missing plot data on environmental variables and problems associated with limited information on plant fire response mechanisms have been outlined before.

The other main data limitation is the relatively restricted number of plots surveyed within the study area. Although the average plot density (438 ha per plot) was intermediate compared to some other surveys which have been conducted within National Parks of the region (e.g. 805 ha per plot in Yengo National Park —Bell et al. 1993; 63 ha per plot in Tomaree National Park — Bell 1997), the distribution of the plots within the study area was very uneven, even when taking into account any uneven variation of environmental characteristics (Fig. 3). Areas well represented by plots include the Royal National Park, the Cockcrow Mountain area, the Whispering Gully area, and the central Barrington Tops plateau. The large central part of the study area, on the other hand, contained only a handful of plots.

On the other hand, the study has benefited from the availability of plot data from areas adjacent to the National Parks. Notwithstanding the comments made above, it has improved the generality of the analytical results, including the delineation of vegetation communities and the determination of significant environmental and fire response mechanism variables.

Conclusions

This study has resulted in the delineation of fourteen vegetation communities, based on 890 plant species and 262 plots, of which 154 were located within the boundaries of the Mount Royal and Barrington Tops National Parks. Eight rare or threatened species were recorded within these plots, most of which occur on the plateaux.

The floristic pattern is most closely related to topographic, geographic, edaphic, and, particularly, climatic variables. 'Years Since Logging' and 'Years Since Last Fire' were also relatively highly correlated, but it should be recognised that much of this data is based on subjective field estimates in relatively few sites, often several years after a fire had occurred.

Data on plant fire response mechanisms are also limited, though sufficient to establish significant relationships between such mechanisms and delineated vegetation communities. Given these results, preliminary suggestions were made regarding the intensity of fires required to affect particular floristic outcomes. There is a need for a longer and more extensive record of fires within the study area in order to relate the occurrence of fires with the nature of vegetation communities.

The objectivity of the results obtained from such studies (and hence the appropriateness of their application) would improve if they were based on floristic data from a larger number of plots within the study area than those used in the present study. Such extra plots should particularly be placed in areas presently under-represented within the data set, such as the large central and north-eastern parts of the study area.

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Appendix A. List of species, showing the percentage of plots per community in which each species is present.

Species	**Community Number (No. of Plots)**													
	1 (34)	**2 (20)**	**3 (19)**	**4 (5)**	**5 (3)**	**6 (43)**	**7 (23)**	**8 (18)**	**9 (48)**	**10 (6)**	**11 (7)**	**12 (9)**	**13 (16)**	**14 (11)**
Acacia barringtonensis	0	0	0	0	0	0	0	0	6	0	29	22	6	0
Acacia dealbata	0	0	5	0	0	0	0	0	42	17	29	0	25	9
Acacia elata	0	10	0	0	0	0	0	0	0	0	0	0	19	9
Acacia implexa	3	15	0	0	0	28	0	0	0	0	0	0	0	0
Acacia irrorata subsp. *irrorata*	3	25	58	40	0	49	4	6	2	0	0	0	0	0
Acacia maidenii	44	15	37	0	0	35	0	6	2	0	0	0	0	0
Acacia melanoxylon	21	25	11	20	33	9	4	28	44	17	71	22	38	9
Acacia obtusifolia	0	0	0	0	0	5	0	0	0	0	0	0	13	0
Acacia stricta	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Acacia ulicifolia	0	5	0	20	0	5	0	0	2	0	0	0	6	0
Acaena novae-zelandiae	71	15	26	0	100	7	0	0	42	83	14	56	19	0
Acaena Unknown	0	0	0	0	0	0	0	6	10	0	14	0	6	0
Acianthus exsertus	0	10	0	0	0	0	0	0	2	0	0	0	0	0
Acianthus fornicatus	3	5	0	0	0	9	0	0	10	0	0	0	0	0
Acianthus Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Acmena smithii	3	5	47	0	0	5	70	83	2	0	0	0	0	9
Acradenia euodiiformis	0	0	5	0	0	2	13	0	0	0	0	0	0	0
Acronychia oblongifolia	0	0	5	0	0	7	9	17	2	0	0	0	0	0
Acrotriche latifolia	0	10	0	0	0	2	0	0	0	0	0	0	0	0
Acrotriche serrulata	0	0	0	0	0	0	0	0	4	0	14	0	0	0
Adiantum aethiopicum	24	0	26	0	0	12	4	0	2	0	0	0	6	0
Adiantum diaphanum	0	5	0	0	0	0	4	6	2	0	0	0	0	0
Adiantum formosum	9	0	42	0	0	12	70	28	0	0	0	0	0	0
Adiantum hispidulum	0	0	5	0	0	9	9	6	0	0	0	0	0	0
Ageratina adenophora	0	5	0	0	0	2	4	0	0	0	0	0	0	0
Ageratina riparia	0	0	11	0	0	0	4	0	0	0	0	0	0	0
Agrostis aemula	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Agrostis avenacea var. *avenacea*	9	0	5	0	33	0	0	0	0	0	0	11	0	0
Ajuga australis	9	5	0	0	0	5	0	0	6	17	0	0	0	0
Alangium villosum subsp. *polyosmoides*	0	0	0	0	0	0	43	0	0	0	0	0	0	0
Alectryon subcinereus	0	0	32	0	0	9	70	33	0	0	0	0	0	0
Allocasuarina littoralis	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Allocasuarina torulosa	53	50	47	0	0	70	0	6	0	0	0	0	0	0

Species	**Community Number (No. of Plots)**													
	1 (34)	**2 (20)**	**3 (19)**	**4 (5)**	**5 (3)**	**6 (43)**	**7 (23)**	**8 (18)**	**9 (48)**	**10 (6)**	**11 (7)**	**12 (9)**	**13 (16)**	**14 (11)**
Alocasia brisbanensis	0	0	5	0	0	0	4	6	0	0	0	0	0	0
Alphitonia excelsa	0	0	5	0	0	2	0	11	0	0	0	0	0	0
Alyxia ruscifolia	0	5	0	0	0	2	13	17	0	0	0	0	0	0
Ambrosia psilostachya	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Ammobium alatum	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Amyema congener subsp. *congener*	9	0	0	0	0	5	0	0	0	0	0	0	0	0
Amyema pendulum subsp. *pendulum*	9	0	5	0	0	2	0	0	0	0	0	0	0	0
Amylotheca dictyophleba	0	0	0	0	0	0	4	6	0	0	0	0	0	0
Anagallis arvensis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Aneilema acuminatum	0	0	37	0	0	5	30	17	2	0	0	0	0	0
Aneilema biflorum	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Angophora floribunda	41	10	5	0	0	16	0	0	0	0	0	0	0	0
Angophora subvelutina	0	0	0	0	0	16	0	0	0	0	0	0	0	0
Aphanopetalum	0	0	11	0	0	0	26	0	0	0	0	0	0	0
Araujia sericiflora resinosum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Archirhodomyrtus beckleri	0	30	0	0	0	5	4	56	0	0	0	0	6	18
Aristida vagans	0	0	0	0	0	9	0	0	0	0	0	0	0	0
Arrhenechthites mixta	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Arthropodium	0	0	0	0	0	0	0	0	2	0	14	0	6	0
Arthropodium milleflorum	44	5	5	20	0	21	0	0	40	17	0	33	13	0
Arthropodium minus	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Arthropodium sp. B	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Arthropteris beckleri	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Arthropteris tenella	0	0	0	0	0	2	87	33	0	0	0	0	0	0
Asperula asthenes	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Asperula conferta	0	0	0	0	0	2	0	0	60	0	0	22	13	0
Asperula gunnii	0	5	0	0	0	0	0	0	4	33	57	44	13	0
Asperula scoparia	6	0	0	0	33	0	0	0	4	0	0	0	6	0
Asplenium australasicum	0	0	16	0	0	0	74	39	0	0	0	0	0	0
Asplenium bulbiferum	0	0	0	0	0	0	4	0	0	0	14	0	0	9
Asplenium flabellifolium	18	5	5	0	0	0	4	0	2	0	14	0	6	0
Asplenium polyodon	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Astrotricha latifolia	0	5	5	0	0	5	4	11	0	0	0	0	13	0

Species	**Community Number (No. of Plots)**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Astrotricha longifolia	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Atherosperma moschatum	0	0	0	0	0	0	0	0	0	0	29	11	0	27
Australina pusilla	0	0	11	0	0	0	9	0	0	0	0	0	0	9
Austrocynoglossum latifolium	38	15	53	0	33	21	4	6	4	0	0	0	0	0
Austromyrtus acmenoides	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Austromyrtus bidwillii	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Backhousia myrtifolia	0	0	16	0	0	0	4	6	0	0	0	0	0	0
Baeckea Unknown	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Baeckea utilis	0	0	0	0	0	0	0	0	0	0	0	33	0	0
Baloghia inophylla	0	0	5	0	0	0	52	6	0	0	0	0	0	0
Banksia integrifolia	0	25	5	20	33	0	0	11	25	0	0	11	57	9
Baumea Unknown	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Berberidopsis beckleri	0	10	0	0	0	0	0	0	2	0	0	0	0	27
Bidens pilosa	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Bidens subalternans	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Billardiera longiflora	0	0	0	0	0	0	0	0	0	0	14	0	6	0
Billardiera scandens	3	40	5	0	0	19	0	0	8	0	0	0	44	0
Blechnum cartilagineum	0	15	11	0	0	7	17	67	2	0	0	0	19	18
Blechnum minus	0	0	0	0	33	0	0	0	2	0	29	22	6	0
Blechnum nudum	0	0	5	0	33	0	0	0	19	0	43	11	19	9
Blechnum patersonii	0	0	0	0	0	0	22	0	0	0	0	0	0	9
Blechnum penna-marina	0	0	0	0	0	0	0	0	2	17	43	33	0	0
Blechnum wattsii	0	5	0	0	0	0	4	0	4	0	14	0	44	36
Bossiaea neo-anglica	0	5	0	20	0	0	0	0	0	0	0	0	0	0
Botrychium australe	6	5	5	0	0	9	0	0	0	0	0	0	0	0
Brachychiton acerifolius	0	0	5	0	0	2	39	17	0	0	0	0	0	0
Brachychiton populneus	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Brachycome diversifolia subsp. *pendulum*	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Brachycome microcarpa	35	10	0	0	0	9	0	0	52	0	29	22	19	0
Brachycome nova-anglica	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Brachycome Unknown	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Brachyloma daphnoides	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Bracteantha bracteata	0	0	0	0	0	5	0	0	17	0	14	0	0	0
Breynia oblongifolia	6	15	32	0	0	67	9	17	0	0	0	0	0	0

Species	**Community Number (No. of Plots)**													
	1 (34)	**2 (20)**	**3 (19)**	**4 (5)**	**5 (3)**	**6 (43)**	**7 (23)**	**8 (18)**	**9 (48)**	**10 (6)**	**11 (7)**	**12 (9)**	**13 (16)**	**14 (11)**
Brunoniella australis	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Bulbine bulbosa	0	0	0	0	33	0	0	0	2	0	0	0	0	0
Bulbophyllum exiguum	0	0	5	0	0	0	0	6	0	0	0	0	0	0
Bulbophyllum shepherdii	0	0	5	0	0	0	4	11	0	0	0	0	0	0
Bulbophyllum Unknown	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Bulbostylis densa	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Bursaria longisepala	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Bursaria spinosa	0	5	0	0	0	0	4	17	0	17	0	0	0	0
Caesia parviflora	3	0	0	20	0	0	0	0	0	0	0	0	0	0
Caladenia carnea	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Calanthe triplicata	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Caldcluvia paniculosa	3	25	5	0	0	0	61	83	0	0	0	0	13	18
Callicarpa pedunculata	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Callicoma serratifolia	0	10	11	0	0	0	4	22	0	0	0	0	13	9
Callistemon pallidus	0	0	0	0	0	0	0	0	0	0	29	22	0	0
Callistemon salignus	0	0	11	20	0	12	0	17	0	0	0	0	0	0
Callitriche muelleri	0	0	5	0	0	0	4	0	0	0	0	0	0	0
Callitris macleayana	0	0	0	0	0	2	0	6	0	0	0	0	0	0
Calochlaena dubia	15	30	26	0	0	19	4	11	6	0	0	0	19	0
Canthium coprosmoides	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Cardamine gunnii	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Cardamine lilacina	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Cardamine paucijuga	15	0	0	0	0	0	0	0	8	0	0	22	6	9
Cardamine sp. Y	9	0	0	0	0	0	0	0	4	0	0	22	0	0
Carduus Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Carex appressa	32	0	26	0	100	7	4	0	15	17	14	22	6	9
Carex breviculmis	12	15	5	40	0	16	0	0	29	0	0	0	25	0
Carex brunnea	0	0	16	0	0	0	22	0	0	0	0	0	0	0
Carex declinata	3	0	5	0	0	0	0	6	2	33	0	0	0	0
Carex fascicularis	0	0	0	0	33	0	0	0	0	0	0	22	0	0
Carex gaudichaudiana	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Carex incomitata	3	0	0	0	0	0	0	0	6	0	14	0	19	0
Carex inversa	53	5	16	0	67	7	4	0	13	17	0	0	0	9
Carex lobolepis	0	0	0	0	67	0	0	0	0	0	0	0	0	0
Carex longebrachiata	21	0	21	0	33	5	9	0	0	0	0	0	0	0
Carex Unknown	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Cassia Unknown	0	0	0	0	0	0	4	0	0	0	0	0	0	0

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Cassine australis	0	0	0	0	0	0	26	11	0	0	0	0	0	0
Cassinia arcuata	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Cassinia compacta	15	0	11	0	0	2	0	0	0	0	0	0	0	0
Cassinia leptocephala	0	5	11	20	0	0	0	0	0	0	0	0	6	0
Cassinia quinquefaria	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Cassinia trinerva	0	0	11	0	0	2	0	0	0	0	0	0	0	0
Casuarina cunninghamiana	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Cayratia clematidea	3	0	26	0	0	23	0	6	0	0	0	0	0	0
Cayratia eurynema	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Celastrus australis	3	0	5	0	0	2	13	0	0	0	0	0	0	0
Celastrus subspicata	0	10	11	0	0	5	0	22	0	0	0	0	0	0
Centaurium erythraea	3	0	0	0	0	2	0	0	0	0	0	0	0	0
Centaurium tenuiflorum	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Centella asiatica	6	0	0	0	0	5	0	0	0	0	0	0	0	0
Centipeda Unknown	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Cephalaralia cephalobotrys	3	5	16	0	0	0	26	56	0	0	0	0	6	9
Cerastium fontanum	0	0	0	0	0	0	0	0	2	17	0	0	0	0
Cerastium glomeratum	3	0	0	0	0	0	0	0	6	0	0	0	0	0
Cerastium semidecandrum	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Ceratopetalum apetalum	0	0	5	0	0	0	0	0	0	17	0	0	0	0
Cheilanthes austrotenuifolia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Cheilanthes distans	0	0	0	20	0	2	0	0	2	0	0	0	0	0
Cheilanthes sieberi subsp. *sieberi*	0	0	0	60	0	14	0	0	0	0	0	0	0	0
Chiloglottis diphylla	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Chiloglottis pluricallata	0	0	0	0	0	0	0	0	2	33	14	0	6	0
Chiloglottis trilabra	0	5	5	0	0	2	0	0	31	0	14	0	31	0
Chiloglottis Unknown	0	0	0	0	0	0	0	0	15	0	29	11	19	0
Chorizema parviflorum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Christella dentata	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Cinnamomum oliveri	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Cirsium vulgare	50	15	11	0	67	16	0	6	25	17	0	0	6	0
Cissus antarctica	6	10	47	0	0	51	78	56	0	0	0	0	0	0
Cissus hypoglauca	9	10	58	0	0	49	65	50	0	0	0	0	6	0

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Cissus opaca	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Citriobatus pauciflorus	3	5	53	0	0	14	100	83	2	0	0	0	0	9
Citronella moorei	0	0	5	0	0	0	30	0	0	0	0	0	0	0
Claoxylon australe	0	0	11	0	0	5	39	6	0	0	0	0	0	0
Clematis aristata	44	55	63	20	0	63	4	17	77	17	43	0	50	55
Clematis glycinoides	0	5	16	0	0	12	4	17	0	0	0	0	0	0
Clerodendrum floribundum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Clerodendrum tomentosum	3	0	11	0	0	16	0	6	0	0	0	0	0	0
Comesperma ericinum	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Comesperma volubile	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Commelina cyanea	6	0	5	0	0	2	4	0	0	0	0	0	0	0
Commersonia fraseri	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Convolvulus erubescens	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Conyza albida	32	10	0	0	0	21	0	0	8	0	0	0	6	0
Conyza bonariensis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Coprosma hirtella	0	0	0	0	0	0	0	0	4	17	29	0	6	0
Coprosma nitida	0	0	0	0	0	0	0	0	2	0	57	0	6	0
Coprosma quadrifida	18	15	32	0	0	0	0	0	40	0	29	22	63	64
Correa reflexa var. *reflexa*	0	0	5	60	0	0	0	0	0	0	0	0	0	0
Corybas aconitiflorus	0	5	0	0	0	5	0	0	0	0	0	0	0	0
Corybas fimbriatus	0	5	5	0	0	0	0	0	0	0	0	11	0	0
Corybas pruinosus	0	0	5	0	0	5	0	0	0	0	0	0	0	0
Corymbia intermedia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Corymbia maculata	0	0	5	0	0	7	0	0	0	0	0	0	0	0
Craspedia variabilis	0	0	0	0	0	0	0	0	0	33	14	11	0	0
Crassula sieberiana	9	0	5	20	0	5	0	0	4	0	0	0	0	0
Crepis capillaris	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Croton verreauxii	0	0	11	0	0	2	4	11	0	0	0	0	0	0
Cryptocarya erythroxylon	0	0	0	0	0	0	30	11	0	0	0	0	0	0
Cryptocarya foveolata	0	0	0	0	0	0	22	0	0	0	0	0	0	0
Cryptocarya glaucescens	0	15	26	0	0	9	48	83	0	0	0	0	0	0
Cryptocarya meissneriana	0	10	11	0	0	0	26	22	0	0	0	0	0	0
Cryptocarya microneura	0	0	21	0	0	9	26	50	0	0	0	0	0	0

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Cryptocarya obovata	0	0	5	0	0	0	43	22	0	0	0	0	0	0
Cryptocarya rigida	0	15	16	0	0	14	9	56	0	0	0	0	0	0
Cyathea australis	3	35	5	0	0	2	0	33	6	0	0	0	19	18
Cyathea leichhardtiana	0	0	0	0	0	0	39	17	0	0	0	0	0	9
Cymbidium suave	0	10	16	0	0	35	0	11	0	0	0	0	0	0
Cymbonotus lawsonianus	0	0	0	0	0	0	0	0	2	0	14	0	0	0
Cymbonotus preissianus	0	0	0	0	0	0	0	0	4	17	0	0	0	0
Cymbopogon refractus	6	5	0	40	0	16	0	0	0	0	0	0	0	0
Cynoglossum australe	6	0	0	0	0	0	0	0	2	0	0	0	0	0
Cynoglossum suaveolens	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Cyperus enervis	3	0	0	0	0	2	4	0	0	0	0	0	0	0
Cyperus flaccidus	6	0	5	0	0	0	0	0	0	0	0	0	0	0
Cyperus gracilis	0	0	0	0	0	2	0	0	0	0	0	0	6	0
Cyperus imbecillis	24	0	16	0	0	2	0	0	0	0	0	0	0	0
Cyperus laevis	0	0	5	0	0	12	0	0	0	0	0	0	0	0
Cyperus lhotskyanus	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Cyperus lucidus	6	0	0	0	67	0	4	0	0	0	0	0	6	0
Cyperus sphaeroideus	0	0	0	0	33	0	0	0	0	0	0	11	0	0
Cyperus tetraphyllus	0	0	26	0	0	7	22	17	0	0	0	0	0	0
Cyperus Unknown	3	5	0	0	0	0	4	0	4	0	0	0	0	0
Cytisus scoparius var. *scoparius*	0	0	0	0	0	0	0	0	10	100	0	33	0	0
Danthonia laevis	3	0	0	0	0	0	0	0	2	0	0	0	0	0
Danthonia longifolia	0	5	0	20	0	5	0	0	0	0	0	0	0	0
Danthonia pilosa	34	5	0	0	0	0	0	0	6	17	0	0	0	0
Danthonia tenuior	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Daphnandra sp. A	9	5	26	0	0	5	74	61	0	0	0	0	0	0
Daucus glochidiatus	6	0	5	0	0	9	0	0	0	0	0	0	0	0
Davallia pyxidata	3	0	5	0	0	7	13	11	0	0	0	0	0	0
Daviesia acicularis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Daviesia genistifolia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Daviesia ulicifolia	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Deeringia amaranthoides	0	0	11	0	0	0	4	0	0	0	0	0	0	0
Dendrobium fairfaxii	0	0	0	0	0	0	9	17	0	0	0	0	0	0
Dendrobium falcorostrum	0	5	0	0	0	0	0	0	0	0	0	0	6	18

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Dendrobium gracilicaule	0	0	0	0	0	0	13	0	0	0	0	0	0	0
Dendrobium mortii	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Dendrobium pugioniforme	0	0	5	0	0	0	35	22	0	0	0	0	0	18
Dendrobium schoeninum	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Dendrobium tarberi	0	0	0	0	0	0	26	0	0	0	0	0	0	0
Dendrobium tetragonum	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Dendrocnide excelsa	0	5	16	0	0	2	57	11	0	0	0	0	0	0
Dendrophthoe vitellina	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Dennstaedtia davallioides	0	0	26	0	0	0	17	17	0	0	0	0	0	9
Derris involuta	0	0	0	0	0	2	0	0	0	0	0	0	6	0
Desmodium brachypodum	0	10	0	0	0	9	0	0	0	0	0	0	0	0
Desmodium rhytidophyllum	0	15	0	0	0	40	0	0	0	0	0	0	0	0
Desmodium varians	91	45	68	40	33	88	0	0	46	0	0	0	25	0
Deyeuxia acuminata	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Deyeuxia gunniana	0	0	0	0	0	0	0	0	0	0	0	22	6	0
Deyeuxia mesathera	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Deyeuxia monticola	0	0	0	0	0	0	0	0	6	17	0	0	0	0
Deyeuxia parviseta	0	5	0	0	0	0	0	0	2	0	14	0	13	0
Deyeuxia quadriseta	3	0	0	0	0	0	0	0	2	0	0	0	0	0
Deyeuxia reflexa	0	0	0	0	0	0	0	0	2	17	0	0	0	0
Deyeuxia rodwayi	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Dianella caerulea	79	60	74	20	0	83	4	17	35	0	29	0	63	27
Dianella longifolia	3	5	0	0	0	14	0	0	0	0	0	11	0	0
Dianella revoluta	6	0	0	20	0	9	0	6	8	0	0	0	0	0
Dianella tasmanica	15	10	0	0	33	0	0	0	25	0	14	0	31	0
Dichelachne inaequiglumis	0	0	0	0	0	2	0	0	4	0	0	0	0	0
Dichelachne micrantha	18	5	0	20	0	2	0	0	17	0	0	0	0	0
Dichelachne rara	9	10	0	0	0	2	0	0	35	17	0	0	19	0
Dichondra repens	85	15	47	20	0	56	0	0	71	17	0	22	31	18
Dichopogon fimbriatus	0	0	0	0	0	0	0	0	0	17	14	11	0	0
Dichopogon strictus	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Dicksonia antarctica	0	5	11	0	0	0	17	0	10	17	86	0	38	82

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Dictymia brownii	0	0	11	0	0	0	43	28	0	0	0	0	0	0
Digitaria parviflora	0	0	5	0	0	14	0	0	0	0	0	0	0	0
Digitaria ramularis	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Dillwynia juniperina	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Dioscorea transversa	6	5	47	0	0	19	39	56	0	0	0	0	6	0
Diospyros australis	6	15	47	0	0	26	57	78	0	0	0	0	0	0
Diospyros fasciculosa	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Diospyros pentamera	0	0	5	0	0	0	48	11	0	0	0	0	0	0
Diplazium assimile	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Diploglottis australis	0	0	16	0	0	16	74	28	0	0	0	0	0	9
Dipodium punctatum	15	5	0	0	0	2	0	0	0	0	0	0	0	0
Dipodium Unknown	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Diuris sulphurea	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Diuris venosa	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Dodonaea megazyga	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Dodonaea viscosa subsp. *angustifolia*	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Doodia aspera	47	10	74	0	0	40	39	33	6	0	0	0	0	9
Doodia caudata	3	0	0	0	0	5	0	0	0	0	0	0	0	0
Doodia media	3	0	5	0	0	0	4	0	0	0	0	0	0	0
Doryphora sassafras	0	15	26	0	0	0	74	28	2	0	0	0	19	82
Drymophila moorei	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Dysoxylum fraserianum	0	10	5	0	0	14	74	50	0	0	0	0	0	0
Echinopogon caespitosus	0	0	0	0	0	14	0	0	0	0	0	0	0	0
Echinopogon ovatus	65	30	37	0	0	12	4	0	48	0	14	0	6	0
Ehretia acuminata	0	0	5	0	0	5	17	12	0	0	0	0	0	0
Einadia hastata	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Elaeocarpus holopetalus	0	0	0	0	0	0	0	0	8	0	57	11	25	27
Elaeocarpus kirtonii	0	0	5	0	0	0	17	0	0	0	0	0	0	0
Elaeocarpus obovatus	0	0	11	0	0	2	0	0	0	0	0	0	0	0
Elaeocarpus reticulatus	6	20	11	0	0	5	4	56	2	0	0	0	0	0
Elatine gratioloides	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Elatostema reticulatum	0	0	5	0	0	0	35	0	0	0	0	0	0	0
Elattostachys nervosa	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Eleocharis gracilis	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Eleocharis sphacelata	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Elymus scaber	24	0	5	20	0	2	0	0	8	0	0	0	0	0

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	1 (34)	2 (20)	3 (19)	4 (5)	5 (3)	6 (43)	7 (23)	8 (18)	9 (48)	10 (6)	11 (7)	12 (9)	13 (16)	14 (11)
Embelia australiana	0	0	0	0	0	0	13	17	0	0	0	0	0	0
Empodisma minus	0	0	0	0	0	0	0	0	0	33	0	44	0	0
Endiandra muelleri	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Endiandra sieberi	0	5	5	0	0	5	17	39	0	0	0	0	0	0
Entolasia marginata	3	10	16	0	0	30	0	0	0	0	0	0	0	0
Entolasia stricta	3	0	0	60	0	21	4	0	0	0	0	0	0	0
Epacris breviflora	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Epacris microphylla var. *rhombifolia*	0	0	0	0	0	0	0	0	0	0	0	33	0	0
Epacris Unknown	0	0	0	0	0	0	0	0	0	33	0	22	0	0
Epilobium billardierianum	6	0	0	0	33	2	0	0	6	0	0	44	0	0
Epilobium gunnianum	0	0	0	0	33	0	0	0	0	0	0	22	0	9
Eragrostis benthamii	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eragrostis brownii	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eragrostis leptostachya	0	0	0	20	0	7	0	0	0	0	0	0	0	0
Erigeron pappocromus var. *gunnii*	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Eriochilus cucullatus	0	0	0	0	0	0	0	0	8	0	0	0	0	0
Eucalyptus acmenoides	0	5	16	20	0	56	0	22	0	0	0	0	0	0
Eucalyptus amplifolia	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Eucalyptus biturbinata	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus bridgesiana	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Eucalyptus cameronii	0	5	0	0	0	0	0	6	10	0	0	0	13	0
Eucalyptus campanulata	18	90	21	20	0	30	0	39	8	0	0	0	19	0
Eucalyptus canaliculata	24	0	11	0	0	58	0	0	0	0	0	0	0	0
Eucalyptus carnea	0	0	0	0	0	12	0	0	0	0	0	0	0	0
Eucalyptus cypellocarpa	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Eucalyptus dalrympleana	0	0	0	0	33	0	0	0	50	17	29	44	0	9
Eucalyptus eugenioides	21	5	0	0	0	19	0	0	0	0	0	0	0	0
Eucalyptus fastigata	0	5	0	0	0	0	0	0	48	0	29	11	38	18
Eucalyptus globoidea	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus laevopinea	82	25	42	0	0	19	9	22	19	0	0	0	0	0
Eucalyptus macrorhyncha	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Eucalyptus melliodora	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus microcorys	0	5	21	0	0	16	4	11	0	0	0	0	0	0
Eucalyptus moluccana	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus nitens	0	0	0	0	0	0	0	0	0	0	0	0	0	9

Species	**Community Number (No. of Plots)**													
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	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Eucalyptus nobilis	15	0	5	20	67	0	0	0	27	0	14	11	13	9
Eucalyptus obliqua	18	5	5	0	0	0	0	6	33	0	14	22	88	27
Eucalyptus paniculata	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus pauciflora	3	0	0	0	33	0	0	0	29	50	71	56	0	0
Eucalyptus propinqua	0	0	11	0	0	5	0	0	0	0	0	0	0	0
Eucalyptus punctata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Eucalyptus quadrangulata	18	10	11	20	0	9	4	6	0	0	0	0	0	0
Eucalyptus radiata	0	0	5	0	0	0	0	0	4	0	14	0	6	0
Eucalyptus resinifera	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Eucalyptus saligna	59	50	53	0	0	58	17	89	4	0	0	0	6	9
Eucalyptus siderophloia	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Eucalyptus stellulata	0	0	0	0	0	0	0	0	0	83	0	22	0	0
Eucalyptus tereticornis	6	0	0	20	0	12	0	0	0	0	0	0	0	0
Eucalyptus viminalis	0	0	0	0	0	0	0	0	2	0	14	0	0	0
Euchiton gymnocephalum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Euchiton sphaericum	3	0	0	0	0	2	0	0	2	0	0	0	0	0
Euphrasia ciliolata	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Eupomatia laurina	0	5	16	0	0	7	57	72	0	0	0	0	0	0
Euroschinus falcata	0	0	0	0	0	4	0	6	0	0	0	0	0	0
Eustrephus latifolius	50	25	58	0	0	33	0	22	4	0	0	0	19	9
Exocarpos cupressiformis	3	5	0	40	0	5	0	0	0	0	0	0	0	0
Exocarpos strictus	0	0	5	20	0	2	0	0	0	0	0	0	0	0
Facelis retusa	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Ficus coronata	0	0	11	0	0	0	43	0	0	0	0	0	0	0
Ficus obliqua var. *obliqua*	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Fieldia australis	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Fimbristylis dichotoma	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Gahnia aspera	0	5	0	0	0	5	0	11	0	0	0	0	0	0
Gahnia melanocarpa	9	10	26	0	0	16	9	28	6	0	0	11	0	9
Gahnia sieberiana	0	0	0	20	0	5	0	0	8	0	0	0	44	9
Galium binifolium	9	10	11	20	0	0	4	0	10	0	0	0	25	0
Galium ciliare	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Galium curvihirtum	0	0	0	20	0	0	0	0	6	0	0	0	0	0
Galium gaudichaudii	3	0	0	0	0	2	0	0	2	0	14	0	0	0
Galium migrans	3	0	0	0	0	0	0	0	6	0	0	0	6	0

Species	**Community Number (No. of Plots)**													
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Galium propinquum	0	10	5	0	0	5	0	0	21	17	29	11	13	18
Galium Unknown	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaultheria appressa	0	0	0	0	0	0	0	0	2	0	43	11	0	0
Geijera latifolia	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Geitonoplesium cymosum	38	30	63	0	0	40	13	50	0	0	0	0	0	0
Gentianella diemensis	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Geranium molle	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Geranium neglectum	0	0	0	0	33	0	0	0	2	0	0	22	0	0
Geranium potentilloides	77	30	37	0	100	49	9	0	86	0	28	0	51	18
Geranium solanderi	15	5	5	0	0	7	0	0	4	17	0	11	6	0
Geranium Unknown	0	5	0	0	0	0	0	0	4	0	14	0	0	0
Gleichenia dicarpa	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Glochidion ferdinandi	0	0	11	0	0	7	0	12	0	0	0	0	0	0
Glyceria australis	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Glycine clandestina	88	60	68	40	0	74	4	0	83	0	0	0	25	0
Glycine microphylla	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Glycine sp. A	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Glycine tabacina	0	0	0	0	0	2	0	0	2	0	14	0	0	0
Glycine Unknown	0	0	0	0	0	0	4	0	2	0	0	0	0	0
Gmelina leichhardtii	0	0	0	0	0	2	4	6	0	0	0	0	0	0
Gnaphalium coarctatum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Gnaphalium gymnocephalum	47	10	11	20	33	16	0	0	33	0	0	33	6	0
Gnaphalium involucratum	0	0	5	0	33	0	0	0	4	17	0	0	0	0
Gnaphalium Unknown	0	0	0	0	0	2	0	0	13	0	0	22	0	0
Gomphocarpus Unknown	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Gomphocarpus fruticosus	0	0	5	0	0	14	0	0	0	0	0	0	0	0
Gonocarpus humilis	12	5	5	20	0	19	0	0	38	0	14	0	38	0
Gonocarpus micranthus	0	0	0	0	0	0	0	0	0	0	14	33	0	0
Gonocarpus montanus	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Gonocarpus oreophilus	0	0	0	20	0	0	4	0	8	0	0	0	6	9
Gonocarpus tetragynus	35	20	11	0	0	19	0	0	23	0	0	0	6	0
Gonocarpus teucrioides	3	20	0	0	0	12	0	6	19	0	14	33	25	9
Gonocarpus Unknown	0	0	0	0	0	0	0	0	2	0	14	0	0	0
Goodenia hederacea	0	0	0	0	0	2	0	0	0	0	0	0	0	0

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	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Goodenia heterophylla	3	5	0	0	0	14	0	0	0	0	0	0	0	0
Goodenia ovata	0	0	5	0	0	0	0	0	0	0	0	0	13	0
Grammitis billardieri	0	0	5	0	0	0	0	0	0	0	14	0	0	36
Gratiola pedunculata	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Gratiola peruviana	0	0	5	0	67	0	4	0	2	0	29	11	0	9
Gratiola Unknown	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Grevillea arenaria	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Grevillea granulifera	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Guioa semiglauca	0	0	26	0	0	35	39	50	2	0	0	0	0	0
Gymnostachys anceps	9	15	53	0	0	30	65	67	2	0	0	0	0	9
Hakea eriantha	0	0	5	0	0	0	0	0	8	0	0	0	19	0
Hakea microcarpa	0	0	0	0	0	0	0	0	2	67	0	67	0	0
Hakea salicifolia	0	15	5	20	0	0	0	0	0	0	0	0	13	0
Haloragis heterophylla	38	0	11	0	67	0	0	0	2	0	0	0	0	0
Haloragis serra	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Hardenbergia violacea	41	50	11	20	0	65	0	0	19	0	0	0	6	0
Hedycarya angustifolia	6	25	26	0	0	0	0	6	4	0	0	0	6	18
Helichrysum apiculatum	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Helichrysum bracteatum	6	10	5	0	0	12	0	0	19	0	0	0	6	0
Helichrysum dendroideum	0	0	0	0	0	0	0	0	2	0	0	11	0	0
Helichrysum elatum	0	0	0	40	0	2	0	0	0	0	0	0	0	0
Helichrysum scorpioides	9	0	0	0	0	0	0	0	46	33	14	0	0	0
Helichrysum Unknown	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Helicia glabriflora	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Hibbertia acicularis	0	0	0	40	0	0	0	0	0	0	0	0	0	0
Hibbertia aspera	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hibbertia dentata	29	50	37	0	0	30	0	28	6	0	0	0	13	0
Hibbertia empetrifolia	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hibbertia linearis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hibbertia obtusifolia	6	0	5	20	0	0	0	0	10	0	0	0	0	0
Hibbertia scandens	56	90	68	0	0	79	0	17	10	0	0	0	6	9
Hibiscus heterophyllus	0	0	0	20	0	4	0	0	0	0	0	0	0	0
Histiopteris incisa	3	5	0	0	0	0	0	6	2	0	0	0	19	45
Holcus lanatus	0	0	0	0	33	0	0	0	0	0	0	0	6	0
Hovea linearis	0	0	0	0	0	0	0	0	4	0	0	22	0	0
Hovea longifolia	0	0	0	20	0	0	0	0	0	0	0	0	6	0
Hovea rosmarinifolia	0	0	0	0	0	0	0	0	0	0	0	11	0	0

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	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Hybanthus enneaspermus	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hybanthus monopetalus	0	0	0	0	0	0	0	0	13	0	0	11	0	0
Hybanthus stellarioides	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hydrocotyle acutiloba	62	5	47	0	0	26	0	0	27	17	0	0	0	0
Hydrocotyle geraniifolia	0	0	11	0	0	5	0	0	4	0	0	0	13	0
Hydrocotyle laxiflora	15	20	21	20	0	12	0	6	60	17	71	11	69	27
Hydrocotyle pedicellosa	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Hydrocotyle peduncularis	9	15	5	20	100	16	0	6	19	33	0	22	6	0
Hydrocotyle tripartita	3	0	0	0	0	2	9	0	0	17	0	22	0	0
Hydrocotyle Unknown	0	0	0	0	0	0	0	0	4	17	0	0	0	0
Hymenanthera dentata	18	0	21	0	0	2	13	0	0	0	0	0	13	0
Hymenophyllum australe	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Hymenophyllum cupressiforme	0	0	0	0	0	0	4	6	0	0	0	0	0	36
Hymenosporum flavum	0	0	32	0	0	5	30	11	0	0	0	0	0	0
Hypericum gramineum	24	15	11	80	0	19	0	0	13	33	14	33	0	0
Hypericum japonicum	6	10	0	0	33	2	0	0	10	0	0	22	0	9
Hypochoeris radicata	53	15	0	0	33	14	0	0	40	33	0	56	6	0
Hypolepis glandulifera	9	0	26	0	33	0	0	6	0	0	0	0	0	0
Hypolepis muelleri	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Hypoxis hygrometrica	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Imperata cylindrica	41	55	37	40	67	90	0	0	0	0	0	0	0	0
Indigofera australis	21	20	26	0	0	23	0	0	2	0	0	0	0	0
Isolepis crassiuscula	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Isolepis habra	0	0	0	0	0	0	0	0	0	0	14	11	6	0
Jacksonia scoparia	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Jasminum volubile	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Juncus alexandri subsp. *melanobasis*	0	0	0	0	33	0	0	0	4	0	0	0	0	0
Juncus articulatus	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Juncus australis	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Juncus filicaulis	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Juncus homalocaulis	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Juncus laeviusculus subsp. *laeviusculus*	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Juncus pauciflorus	21	0	16	0	67	2	9	0	0	0	0	11	0	0
Juncus phaeanthus m.s.	0	0	0	0	0	0	0	0	2	0	0	0	0	0

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Juncus prismatocarpus	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Juncus sandwithii	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Juncus sarophorus	9	0	5	0	67	0	0	0	0	0	0	0	0	0
Juncus Unknown	0	10	0	0	0	0	0	0	2	0	14	0	0	9
Juncus usitatus	0	0	0	0	0	2	0	6	0	0	0	0	0	0
Juncus vaginatus	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Kennedia rubicunda	6	20	0	0	0	16	0	0	0	0	0	0	0	0
Kennedia Unknown	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Lagenaria Unknown	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Lagenifera gracilis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Lagenifera stipitata	21	15	16	20	0	19	0	0	38	0	29	0	44	18
Lantana camara	0	0	5	0	0	7	0	0	0	0	0	0	0	0
Lastreopsis acuminata	3	0	0	0	0	2	30	6	0	0	0	0	0	0
Lastreopsis decomposita	0	0	11	0	0	0	43	22	0	0	0	0	0	0
Lastreopsis microsora	0	0	11	0	0	0	57	6	0	0	0	0	6	0
Lastreopsis munita	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Lastreopsis Unknown	0	0	0	0	0	0	0	11	2	0	0	0	0	0
Legnephora moorei	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Lepidosperma elatius	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Lepidosperma laterale	50	25	42	100	0	44	0	6	15	0	0	0	63	9
Lepidosperma tortuosum	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Leptinella filicula	0	0	0	0	0	0	0	0	35	0	43	0	19	9
Leptospermum argenteum	0	0	0	0	0	0	0	0	2	0	0	44	0	0
Leptospermum polygalifolium	3	0	0	0	0	0	0	0	4	0	43	22	19	0
Leptospermum variabile	0	0	0	40	0	0	0	0	2	0	0	0	0	0
Leucopogon fraseri	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Leucopogon hookeri	0	0	0	0	0	0	0	0	58	67	71	44	13	0
Leucopogon juniperinus	0	0	5	20	0	9	0	0	0	0	0	0	0	0
Leucopogon lanceolatus	29	35	16	40	0	0	0	0	67	0	0	22	69	9
Libertia paniculata	3	0	5	0	0	0	0	0	6	0	0	0	6	0
Libertia pulchella	0	0	0	0	0	0	0	0	0	0	14	11	6	0
Lilaeopsis polyantha	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Lindsaea linearis	0	0	0	0	0	0	0	0	10	0	0	11	0	0
Lindsaea Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Lissanthe strigosa	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Litsea reticulata	0	10	5	0	0	7	26	44	0	0	0	0	0	0

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	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Livistona australis	0	0	0	0	0	2	4	0	0	0	0	0	0	0
Lobelia gibbosa	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Lobelia trigonocaulis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Logania albiflora	0	0	0	40	0	2	0	0	0	0	0	0	0	0
Lomandra confertifolia	0	5	0	0	0	0	0	6	2	0	0	0	0	0
Lomandra filiformis	0	5	0	0	0	18	0	0	4	0	0	0	0	0
Lomandra hystrix	0	0	11	0	0	0	4	6	0	0	0	0	0	0
Lomandra longifolia	97	90	74	80	100	93	0	33	90	0	28	33	88	27
Lomandra multiflora	0	0	0	20	0	7	0	0	2	0	0	0	0	0
Lomandra spicata	0	0	21	0	0	0	87	44	0	0	0	0	0	27
Lomatia arborescens	0	15	0	0	0	0	0	17	10	0	14	11	44	0
Lomatia fraseri	0	10	0	0	0	0	0	0	4	0	14	11	6	0
Lophostemon confertus	0	0	0	0	0	5	0	6	0	0	0	0	0	0
Lotus corniculatus	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Luzula densiflora	0	0	0	0	0	0	0	0	10	17	14	0	0	0
Luzula flaccida	0	0	0	0	0	0	0	0	17	17	14	0	6	0
Luzula ovata	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Luzula Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Lycopodium deuterodensum	0	0	0	0	0	0	0	0	0	0	0	22	6	0
Lycopodium fastigiatum	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Maclura cochinchinensis	0	0	5	0	0	5	9	6	0	0	0	0	0	0
Malaisia scandens	0	0	0	0	0	2	26	11	0	0	0	0	0	0
Mallotus philippensis	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Marsdenia flavescens	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Marsdenia lloydii	0	0	0	0	0	2	4	6	0	0	0	0	0	0
Marsdenia rostrata	6	5	5	0	0	5	30	6	0	0	0	0	0	9
Maytenus silvestris	21	0	47	20	0	42	0	6	4	0	0	0	0	0
Medicago polymorphua	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Melaleuca styphelioides	6	0	5	0	0	5	0	0	0	0	0	0	0	0
Melia azedarach var. *australasica*	0	0	0	0	0	9	0	0	0	0	0	0	0	0
Melichrus urceolatus	0	0	0	40	0	0	0	0	4	0	0	0	0	0
Melicope micrococca	0	5	16	0	0	16	17	28	0	0	0	0	0	0
Melodinus australis	0	0	5	0	0	0	13	0	0	0	0	0	0	0
Mentha diemenica	24	5	0	0	0	5	0	0	0	0	0	0	0	0
Mentha satureioides	0	0	0	0	0	2	0	0	0	17	0	0	0	0
Micrantheum hexandrum	0	0	0	20	0	0	0	0	0	0	0	0	0	0

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Micrantheum Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Microlaena stipoides	44	30	37	20	0	33	0	0	42	17	29	0	56	9
Microsorum diversifolium	0	0	0	0	0	0	4	6	0	0	14	0	0	9
Microsorum scandens	0	5	11	0	0	0	65	17	0	0	0	0	0	9
Microtis parviflora	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Microtis unifolia	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Mischocarpus australis	0	0	0	0	0	0	48	22	0	0	0	0	0	0
Mischocarpus pyriformis	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Monotoca scoparia	0	0	0	20	0	0	0	0	0	0	0	22	6	0
Morinda jasminoides	0	5	21	0	0	5	74	44	0	0	0	0	0	9
Muellerina celastroides	3	5	0	0	0	5	0	0	0	0	0	0	0	0
Muellerina eucalyptoides	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Myoporum montanum	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Myoporum Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Myosotis australis	0	0	0	0	0	0	0	0	19	0	0	11	6	0
Myosotis exarrhena	3	0	0	0	0	0	0	0	2	0	0	0	0	0
Myriophyllum crispatum	0	0	0	0	33	0	0	0	0	0	14	33	0	0
Neolitsea australiensis	0	0	5	0	0	2	4	22	0	0	0	0	0	0
Neolitsea dealbata	0	0	16	0	0	5	61	33	0	0	0	0	0	0
Notelaea longifolia	0	5	21	0	0	4	4	17	8	0	0	0	19	27
Notelaea neglecta	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Notelaea ovata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Notelaea sp. A	0	0	0	0	0	0	0	0	4	0	0	0	13	0
Notelaea venosa	3	5	5	0	0	0	0	0	6	0	0	0	31	27
Nothofagus moorei	0	15	0	0	0	0	0	0	15	0	14	0	44	100
Olearia alpicola	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Olearia chrysophylla	6	0	5	0	0	0	0	0	0	0	14	33	0	0
Olearia covenyi	0	0	0	0	0	0	0	0	4	0	0	0	19	0
Olearia nernstii	0	5	0	0	0	2	0	0	0	0	0	0	0	0
Olearia oppositifolia	0	0	0	0	0	0	0	0	17	33	57	22	6	0
Olearia phlogopappa	0	0	0	0	0	0	0	0	2	0	14	11	0	0
Olearia Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Olearia viscidula	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Omalanthus populifolius	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Opercularia aspera	0	0	0	20	0	23	0	0	0	0	0	0	0	0
Opercularia diphylla	0	0	0	0	0	2	0	0	0	0	0	0	0	0

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Opercularia hispida	0	10	0	20	0	2	0	0	0	0	0	11	0	0
Oplismenus aemulus	0	5	5	0	0	37	0	0	0	0	0	0	0	0
Oplismenus imbecillis	41	15	63	20	0	44	17	11	0	0	0	0	6	0
Oreomyrrhis ciliata	0	0	0	0	0	0	0	0	0	17	14	0	0	0
Oreomyrrhis eriopoda	6	0	0	0	0	0	0	0	56	50	43	33	13	0
Orites excelsa	0	0	11	0	0	0	48	39	0	0	0	0	0	27
Oxalis chnoodes	3	20	26	0	0	19	0	0	8	0	0	0	0	0
Oxalis exilis	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Oxalis perennans	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Oxalis radicosa	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Oxalis Unknown	3	0	0	0	0	0	0	0	0	0	0	0	6	0
Oxylobium ilicifolium	3	50	0	20	0	14	0	0	15	0	0	0	25	0
Ozothamnus diosmifolius	6	5	0	20	0	19	0	0	2	0	0	0	0	0
Ozothamnus ferrugineus	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Ozothamnus rufescens	15	0	21	0	0	7	9	0	0	0	0	0	0	0
Ozothamnus Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Palmeria scandens	0	10	5	0	0	0	70	50	0	0	0	0	6	0
Pandorea jasminoides	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Pandorea pandorana	44	10	58	0	0	35	70	44	4	0	0	0	13	9
Panicum effusum	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Panicum simile	0	5	0	0	0	12	0	0	0	0	0	0	0	0
Papillilabium beckleri	0	0	5	0	0	2	4	11	0	0	0	0	0	0
Pararchidendron pruinosum	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Parsonsia brownii	0	0	0	0	0	0	0	0	0	0	29	0	19	64
Parsonsia induplicata	0	0	5	0	0	2	0	0	0	0	0	0	0	0
Parsonsia sp. A	0	5	0	20	0	2	13	17	0	0	0	0	0	0
Parsonsia straminea	15	15	47	0	0	21	52	61	2	0	0	0	6	9
Parsonsia velutina	0	0	0	0	0	0	39	0	0	0	0	0	0	0
Paspalidium distans	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Paspalum dilatatum	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Passiflora herbertiana	0	0	0	0	0	14	0	0	0	0	0	0	0	0
Passiflora subpeltata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Patersonia fragilis	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Patersonia glabrata	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Pellaea falcata	38	5	63	0	0	35	43	40	2	0	0	0	0	0

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Pellaea paradoxa	0	5	11	0	0	2	0	0	0	0	0	0	0	0
Pennantia cunninghamii	0	0	5	0	0	0	83	0	0	0	0	0	0	0
Pennisetum alopecuroides	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Peperomia tetraphylla	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Persicaria decipiens	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Persicaria hydropiper	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Persoonia acuminata	0	0	0	0	0	0	0	0	10	0	0	0	6	0
Persoonia chamaepeuce	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Persoonia linearis	9	60	26	20	0	56	0	0	4	0	0	11	38	0
Persoonia media	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Persoonia oleoides	0	5	0	0	0	2	0	0	8	0	0	0	13	0
Persoonia Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Phalaris canariensis	0	5	0	0	0	0	0	6	0	0	0	0	0	0
Phebalium squameum	0	0	0	0	0	0	0	0	0	0	14	0	0	9
Phragmites australis	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Phyllanthus gasstroemii	0	10	11	20	0	2	4	0	0	0	0	0	0	0
Phyllanthus gunnii	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Phyllanthus similis	3	0	11	0	0	5	0	6	0	0	0	0	0	0
Phyllanthus Unknown	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Physalis minima	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Phytolacca octandra	3	0	0	0	0	0	4	0	0	0	0	0	0	0
Picris hieracioides	29	5	5	0	0	5	0	0	17	0	0	0	0	0
Pimelea curviflora var. *curviflora*	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Pimelea glauca	0	0	0	0	0	0	0	0	0	33	0	0	0	0
Pimelea ligustrina	0	0	5	0	0	0	0	12	8	0	14	0	19	9
Pimelea linifolia	0	5	0	0	0	0	0	0	0	34	0	22	0	0
Pimelea neo-anglica	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Piper novae-hollandiae	0	0	5	0	0	0	39	11	0	0	0	0	0	0
Pittosporum revolutum	15	10	21	0	0	16	4	33	0	0	0	0	0	0
Pittosporum undulatum	12	35	21	20	0	12	9	33	0	0	0	0	0	0
Planchonella australis	0	0	0	0	0	2	13	17	0	0	0	0	0	0
Plantago cladarophylla	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Plantago debilis	65	15	37	0	0	26	0	0	33	0	0	0	25	0
Plantago Unknown	0	0	0	0	0	0	0	0	2	33	0	0	0	0
Platycerium bifurcatum	9	0	16	0	0	12	43	45	0	0	0	0	0	0
Platysace lanceolata	0	5	0	20	0	2	0	0	0	0	0	0	0	0

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Plectorrhiza tridentata	0	0	5	0	0	2	13	6	0	0	0	0	0	0
Plectranthus graveolens	0	0	0	20	0	2	4	0	0	0	0	0	0	0
Plectranthus parviflorus	41	10	42	40	0	67	13	0	2	0	0	0	0	0
Plectranthus Unknown	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Poa Costiniana	0	0	0	0	0	0	0	0	2	0	0	33	0	0
Poa labillardieri	100	20	42	20	100	74	4	0	15	33	0	0	6	0
Poa queenslandica	0	5	0	0	0	5	4	0	2	0	0	0	0	0
Poa sieberiana	3	25	26	40	0	24	0	0	100	50	71	55	81	18
Poa Unknown	0	0	0	0	0	0	0	0	0	17	29	0	0	0
Podocarpus elatus	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Pollia crispata	0	0	0	0	0	0	30	11	0	0	0	0	0	0
Polygala japonica	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Polymeria calycina	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Polyosma cunninghamii	0	10	5	0	0	0	61	44	0	0	0	0	0	9
Polyphlebium venosum	0	0	0	0	0	0	0	0	0	0	0	0	0	18
Polyscias elegans	0	0	5	0	0	2	4	22	0	0	0	0	0	0
Polyscias murrayi	0	0	5	0	0	0	9	6	0	0	0	0	0	0
Polyscias sambucifolia	18	40	11	0	0	19	0	0	33	0	0	11	50	0
Polystichum australiense	0	0	0	0	0	0	4	0	8	0	14	0	13	36
Polystichum fallax	24	0	26	0	33	0	0	0	0	0	0	0	0	0
Polystichum proliferum	0	5	0	0	0	0	0	0	10	0	43	11	13	18
Pomaderris andromedifolia	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Pomaderris argyrophylla	0	0	0	20	0	0	0	0	0	0	14	0	13	0
Pomaderris eriocephala	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Pomaderris helianthemifolia	0	0	5	20	0	0	0	0	0	0	0	0	0	0
Pomaderris ligustrina	0	0	5	20	0	0	0	0	2	0	0	0	6	0
Poranthera microphylla	38	15	5	20	0	21	0	0	81	33	14	11	25	0
Prasophyllum fuscum	0	0	0	0	0	0	0	0	0	17	0	11	0	0
Pratia pedunculata	15	10	0	0	33	0	0	0	69	17	71	44	44	9
Pratia purpurascens	76	30	21	20	67	51	0	0	29	0	14	0	6	0
Pratia surrepens	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Prostanthera incisa	0	10	0	0	0	0	0	6	0	0	0	0	6	0
Prostanthera lasianthos	0	0	0	0	0	0	0	0	4	0	43	11	19	18
Prunella vulgaris	9	5	0	0	100	2	0	0	2	17	0	22	6	0
Pseuderanthemum variabile	0	5	21	0	0	26	0	11	2	0	0	0	0	0

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Psychotria loniceroides	3	35	47	0	0	51	43	72	0	0	0	0	0	0
Pteridium esculentum	85	90	74	0	100	56	0	6	92	17	29	0	94	9
Pteris tremula	9	0	26	0	0	23	4	17	0	0	0	0	0	0
Pteris umbrosa	0	0	0	0	0	0	52	11	0	0	0	0	0	0
Pterostylis abrupta	0	0	0	0	0	0	0	0	13	0	14	11	19	0
Pterostylis coccina	6	0	0	0	0	0	0	0	35	0	0	0	0	9
Pterostylis curta	12	0	0	0	0	0	0	0	2	0	0	0	0	0
Pterostylis decurva	12	10	0	0	0	0	0	0	13	0	14	0	0	0
Pterostylis furcata	0	0	0	0	0	0	0	0	0	0	14	22	0	0
Pterostylis hispidula	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Pterostylis longifolia	0	10	0	20	0	2	0	0	2	0	0	0	0	0
Pterostylis nutans	0	0	0	0	0	9	0	0	4	0	0	0	0	0
Pterostylis obtusa	0	5	0	0	0	2	0	0	0	0	0	0	0	0
Pterostylis parviflora	0	5	0	20	0	0	0	0	0	0	0	0	0	0
Pterostylis Unknown	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Pultenaea fasciculata	0	0	0	0	0	0	0	0	0	17	0	11	0	0
Pultenaea microphylla	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Pultenaea villosa	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Pyrrosia confluens	0	5	21	0	0	2	61	44	4	0	0	0	6	0
Pyrrosia rupestris	35	15	37	20	0	12	17	67	4	0	14	0	13	55
Pyrrosia Unknown	0	0	5	0	0	0	0	6	2	0	0	0	0	0
Quintinia sieberi	0	5	0	0	0	2	0	6	0	0	0	0	0	18
Ranunculus inundatus	3	10	0	0	0	2	0	0	2	0	0	11	0	0
Ranunculus lappaceus	12	0	0	0	33	5	0	0	35	33	14	11	6	0
Ranunculus pimpinellifolius	0	0	0	0	0	0	0	0	0	17	0	56	0	0
Ranunculus plebeius	41	10	5	0	67	2	0	0	10	17	14	11	0	0
Ranunculus pumilio	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Ranunculus Unknown	0	0	0	0	0	0	0	0	8	0	14	0	0	0
Rapanea howittiana	9	0	53	0	0	14	13	17	0	0	0	0	6	0
Rapanea variabilis	6	15	47	20	0	35	4	56	0	0	0	0	0	0
Restio stenocoleus	0	0	0	0	0	0	0	0	0	33	0	78	0	0
Rhagodia spinescens	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Rhinerrhiza divitiflora	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Rhodamnia rubescens	0	0	16	0	0	21	0	56	0	0	0	0	0	0
Rhodanthe anthemoides	6	0	0	0	0	0	0	0	2	0	0	0	0	0
Rhodomyrtus psidioides	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Ripogonum album	0	0	5	0	0	0	30	11	0	0	0	0	0	0

Species	**Community Number (No. of Plots)**													
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Ripogonum discolor	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Ripogonum fawcettianum	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Rostellularia adscendens subsp. *adscendens*	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Rubus hillii	3	0	5	0	0	5	22	6	0	0	0	0	0	0
Rubus moorei	0	5	0	0	0	0	4	6	0	0	0	0	0	0
Rubus parvifolius	74	40	37	0	67	67	0	6	67	0	14	22	25	0
Rubus rosifolius	21	25	53	0	33	35	9	28	4	0	0	0	0	0
Rubus sp. A	0	0	5	0	0	0	13	6	0	0	0	0	0	0
Rumex brownii	26	0	16	0	67	0	0	0	2	17	14	0	0	0
Sambucus australasica	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Sambucus gaudichaudiana	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Santalum obtusifolium	0	0	11	0	0	2	0	0	2	0	0	0	0	0
Sarcochilus australis	0	0	5	0	0	0	4	0	0	0	0	0	0	0
Sarcochilus falcatus	3	10	16	0	0	7	57	67	0	0	0	0	0	18
Sarcochilus hillii	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Sarcochilus olivaceus	0	0	5	0	0	0	17	6	0	0	0	0	0	0
Sarcochilus spathulatus	0	0	0	0	0	0	4	11	0	0	0	0	0	0
Sarcochilus Unknown	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Sarcomelicope simplicifolia	0	0	0	0	0	2	4	6	0	0	0	0	0	0
Sarcopetalum harveyanum	3	0	16	0	0	2	22	22	0	0	0	0	0	0
Scaevola albida	3	0	0	0	0	2	0	0	0	0	0	0	0	0
Scaevola hookeri	0	0	0	0	0	0	0	0	0	17	0	22	0	0
Schizomeria ovata	3	25	16	0	0	7	39	72	0	0	0	0	6	18
Schoenus apogon	9	0	0	0	67	5	0	0	6	0	0	11	0	9
Scirpus polystachyus	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Scirpus Unknown	0	0	0	0	0	0	0	0	0	17	0	0	0	0
Scleranthus biflorus	6	0	0	0	0	0	0	0	17	33	0	0	13	0
Scleria mackaviensis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Scutellaria humilis	9	0	11	20	0	0	0	0	0	0	0	0	0	0
Scutellaria mollis	0	5	21	0	0	5	0	0	4	0	0	0	19	9
Senecio amygdalifolius	24	15	47	0	0	14	4	6	0	0	0	0	0	0
Senecio bipinnatisectus	0	0	5	0	0	0	4	0	0	0	0	0	0	0
Senecio biserratus	3	5	0	0	0	0	0	0	23	0	0	0	19	0
Senecio diaschides	3	10	0	0	0	7	0	0	29	0	0	0	6	0

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Senecio gunnii	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Senecio hispidulus	24	5	5	0	0	0	0	0	2	0	0	0	0	0
Senecio lautus	6	0	0	0	0	7	0	0	29	33	14	11	0	0
Senecio linearifolius	21	25	32	0	0	5	0	0	6	0	0	0	13	0
Senecio macranthus	9	0	0	0	0	0	0	0	0	0	0	0	0	0
Senecio madagascariensis	0	0	5	0	0	5	0	0	0	0	0	0	0	0
Senecio minimus	9	0	11	0	33	0	0	0	2	0	0	0	13	0
Senecio sp. aff. *apargiifolius*	47	10	11	0	0	5	0	0	31	0	0	0	6	0
Senecio sp. E	0	0	0	0	0	0	0	0	2	0	14	22	6	0
Senecio squarrosus	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Senecio Unknown	0	0	0	0	0	7	0	0	8	17	29	0	0	0
Senecio vagus	6	0	5	0	0	0	4	0	0	0	0	0	12	0
Senecio velleioides	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Senna odorata	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Setaria pumila	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Sigesbeckia orientalis	47	15	42	0	0	65	0	6	4	0	0	0	13	0
Sloanea australis	0	0	5	0	0	0	39	22	0	0	0	0	0	0
Sloanea woollsii	0	0	0	0	0	0	30	6	0	0	0	0	0	0
Smilax australis	6	30	68	0	0	28	26	89	60	17	100	11	88	91
Smilax glyciphylla	0	10	5	0	0	0	0	17	0	0	0	0	0	0
Solanum aviculare	3	0	16	0	0	0	4	6	0	0	0	0	6	0
Solanum brownii	12	10	21	20	0	16	0	0	0	0	0	0	0	0
Solanum elegans	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Solanum nigrum	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Solanum opacum	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Solanum prinophyllum	15	0	16	20	0	26	4	6	2	0	0	0	0	0
Solanum pseudocapsicum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Solanum pungetium	0	0	0	20	0	2	4	0	0	0	0	0	0	0
Solanum stelligerum	6	5	21	20	0	47	4	11	2	0	0	0	0	0
Solanum Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Solenogyne gunnii	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Sonchus asper subsp. *glaucescens*	3	0	0	0	33	0	0	0	2	0	0	0	0	0
Sonchus oleraceus	3	0	0	0	0	2	0	0	0	0	0	0	0	0
Sorghum leiocladum	12	0	5	0	0	23	0	0	2	0	0	0	0	0
Sparganium subglobosum	0	0	0	0	0	0	0	0	0	0	0	11	0	0

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Spiranthes sinensis	0	0	0	0	0	0	0	0	2	0	0	11	0	0
Sporobolus elongatus	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Sporobolus pyramidalis	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Stackhousia viminea	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Stellaria flaccida	44	10	32	0	0	21	0	0	13	0	57	22	6	9
Stellaria media	6	0	0	0	0	0	0	0	0	0	14	0	0	0
Stellaria pungens	0	0	5	20	0	0	0	0	21	0	0	0	6	0
Stenocarpus salignus	0	10	5	0	0	5	9	17	0	0	0	0	0	0
Stephania japonica	0	0	5	0	0	12	4	0	0	0	0	0	0	0
Sticherus lobatus	0	15	0	0	0	0	0	11	0	0	0	0	31	27
Stipa ramosissima	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Stipa rudis subsp. *nervosa*	0	10	0	20	0	5	0	0	0	0	0	0	0	0
Streblus brunonianus	0	0	5	0	0	0	48	0	0	0	0	0	0	0
Stylidium graminifolium	0	5	0	20	0	0	0	0	6	33	29	22	0	0
Stypandra glauca	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Swainsona galegifolia	3	10	5	0	0	28	0	0	2	0	0	0	0	0
Swainsona Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Symplocos stawellii	0	0	5	0	0	0	9	0	0	0	0	0	0	0
Symplocos thwaitesii	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Syncarpia glomulifera	0	5	16	20	0	33	0	6	0	0	0	0	0	0
Synoum glandulosum	26	25	58	0	0	44	35	94	2	0	0	0	0	0
Syzygium australe	0	0	0	0	0	0	57	6	0	0	0	0	0	0
Syzygium oleosum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Taraxacum officinale	12	0	0	0	0	2	0	0	4	0	0	0	0	0
Tasmannia glaucifolia	0	0	0	0	0	0	0	0	2	17	29	22	0	0
Tasmannia insipida	0	10	21	0	0	0	57	83	0	0	0	0	0	9
Tasmannia purpurascens	3	0	0	0	0	0	0	0	27	17	100	22	13	45
Tasmannia stipitata	0	5	0	0	0	0	4	0	10	0	0	0	25	0
Tetrastigma nitens	0	25	11	0	0	35	13	6	0	0	0	0	6	0
Thelymitra circumsepta	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Thelymitra cyanea	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Thelymitra pauciflora	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Themeda australis	12	10	0	20	0	33	0	0	2	0	0	0	0	0
Todea barbara	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Toona ciliata	0	0	11	0	0	2	26	17	0	0	0	0	0	0
Trema aspera	0	0	0	0	0	5	13	0	0	0	0	0	0	0
Tricoryne elatior	0	0	0	0	0	2	0	0	0	0	0	0	0	0

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	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Trifolium repens	35	5	0	0	67	2	0	0	17	50	0	44	0	0
Trifolium Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Trimenia moorei	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Tripladenia cunninghamii	0	0	11	0	0	0	0	0	0	0	0	0	0	0
Tristaniopsis collina	3	30	11	0	0	2	9	67	8	0	0	0	0	9
Tristaniopsis laurina	0	0	11	0	0	0	0	6	0	0	0	0	0	0
Trochocarpa laurina	0	30	11	0	0	12	9	67	4	0	0	0	6	18
Trochocarpa sp. A	3	10	0	0	0	0	0	0	17	0	14	0	44	9
Trochocarpa sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	0	9
Trochocarpa Unknown	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Tylophora barbata	9	15	5	0	0	19	0	6	4	0	0	0	6	0
Tylophora paniculata	0	5	16	0	0	14	0	17	0	0	0	0	6	9
Typha orientalis	0	0	0	0	33	0	0	0	0	0	0	0	0	0
Typhonium brownii	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Uncinia nemoralis	0	0	0	0	0	0	0	0	0	0	14	0	0	9
Urtica incisa	38	5	53	0	67	5	17	28	6	17	14	11	13	45
Utricularia dichotoma	0	0	0	0	0	0	0	0	0	0	0	44	0	0
Verbena bonariensis	0	0	0	0	33	2	0	0	0	0	0	0	0	0
Verbena officinalis	3	0	0	0	33	0	0	0	0	0	0	0	0	0
Verbena rigida	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Vernonia cinerea	6	15	5	0	0	40	0	0	0	0	0	0	0	0
Veronica calycina	50	5	16	0	0	2	0	0	29	17	0	0	6	0
Veronica notabilis	0	5	11	0	0	0	0	6	17	0	43	22	19	64
Veronica persica	0	0	0	0	0	0	0	0	0	17	14	0	0	0
Veronica plebeia	6	5	0	0	0	19	0	0	2	0	0	0	0	0
Veronica sp.C	0	0	5	0	0	5	0	6	6	0	0	0	13	0
Veronica sp. B	0	0	5	0	0	0	0	0	27	33	43	11	38	9
Veronica Unknown	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Vesselowskya rubifolia	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Viola betonicifolia	50	30	0	0	0	30	0	0	75	33	29	11	0	0
Viola hederacea	50	40	63	0	33	30	9	17	79	67	100	33	63	18
Viola sp. A	0	0	0	0	0	0	0	0	0	17	0	11	0	0
Vittadinia cuneata	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Vittadinia dissecta	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Vittadinia tenuissima	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Wahlenbergia ceracea	0	0	0	0	0	0	0	0	25	33	0	22	0	0

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	(34)	**(20)**	**(19)**	**(5)**	**(3)**	**(43)**	**(23)**	**(18)**	**(48)**	**(6)**	**(7)**	**(9)**	**(16)**	**(11)**
Wahlenbergia gracilis	0	5	0	0	0	2	0	0	0	0	14	0	0	0
Wahlenbergia littoricola	0	10	0	0	0	2	0	0	2	0	0	0	0	0
Wahlenbergia stricta	65	15	11	0	33	10	0	0	42	17	14	33	19	0
Wahlenbergia Unknown	0	0	0	0	0	0	0	0	6	0	0	0	0	0
Waterhousea floribunda	0	0	5	0	0	0	0	0	0	0	0	0	0	0
Westringia eremicola	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Wilkiea huegeliana	0	0	5	0	0	2	9	33	0	0	0	0	0	0
Xanthorrhoea glauca	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Xanthorrhoea Unknown	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Youngia japonica	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Zanthoxylum brachyacanthum	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Ziera smithii subsp. A	0	0	0	0	0	0	0	0	0	0	0	0	6	0
Zieria arborescens	0	0	0	0	0	0	0	6	0	0	0	0	0	0
Zieria pilosa	0	0	0	20	0	0	0	0	0	0	0	0	0	0
Zieria smithii	0	0	5	20	0	5	4	0	0	0	0	0	0	0
Zieria sp. K	0	5	0	0	0	2	0	0	2	0	0	0	6	0

Community 1: *Eucalyptus laevopinea* –*Eucalyptus saligna* open forest over *Poa labillardieri* grass and herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus laevopinea, Eucalyptus saligna, Allocasuarina torulosa, Eucalyptus obliqua, Eucalyptus campanulata, Eucalyptus canaliculata, Angophora floribunda*
- Vines *Desmodium varians, Glycine clandestina, Rubus parvifolius, Hibbertia scandens, Eustrephus latifolius*
- Herbs *Lomandra longifolia, Dichondra repens, Dianella caerulea, Pratia purpurascens, Acaena novae-zelandiae, Geranium potentilloides, Plantago debilis, Hydrocotyle acutiloba, Wahlenbergia stricta, Carex inversa, Hypochoeris radicata, Cirsium vulgare, Lepidosperma laterale, Viola betonicifolia, Viola hederacea*
- Grasses *Poa labillardieri Echinopogon ovatus, Oplismenus imbecillis, Imperata cylindrica, Microlaena stipoides*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

Senecio macranthus, Tasmannia purpurascens.

Relationship to Other Communities

Related to Vegetation Community 2–6 (*Eucalyptus* spp. forest of lower altitudes), but the most distinctive of these communities.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 10.1 (E.saligna)
BARov 17.1 *(E.laevopinea)*
BARov 18 *(E.obliqua)*
BARus 16 *(Acacia irrorata-Doodia aspera)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*

Hager & Benson (1994)

EF011e *(E.saligna-E.quadrangulata)*
EF475g *(E.obliqua-E.laevopinea)*
EF479a *(E.laevopinea)*
EF479e *(E.saligna-E.laevopinea)*
Specht et al. (1995)
199 *(E. laevopinea)*

Distribution

Inside National Park boundaries

Very common in Mount Royal National Park and Cockcrow Mountain areas.

Outside National Park Boundaries

Occurs on well drained, fertile soils on eastern escarpment of the Northern Tablelands.

Environmental Correlates

Occurs on lower slopes, in moderately moist, fertile soils, in moderately steep terrain.

Threats

Exotic Species

Centaurium erythraea, Centella asiatica, Conyza albida, Phytolacca octandra, Sonchus asper, Taraxacum officinale, Verbena officinalis.

Fire

Subject to fires from adjacent farm properties.

Information for Fire Management

Average Total Number of Species:	Species With Known Plant Responses:	Resprouter: Seeder Ratio:
47.03	46%	0.86

Known Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Asperula scoparia
Billardiera scandens
Breynia oblongifolia
Centaurium erythraea
Cerastium glomeratum
Cirsium vulgare
Clematis aristata
Crassula sieberiana
Daucus glochidiatus
Davallia pyxidata
Dichondra repens
Echinopogon ovatus
Galium binifolium
Galium gaudichaudii
Geranium potentilloides
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Sonchus oleraceus
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Hypolepis glandulifera
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Oxylobium ilicifolium
Pandorea pandorana
Phytolacca octandr
Pittosporum undulatum
Poranthera microphylla
Pyrrosia rupestris
Rapanea howittiana
Scaevola albida
Schoenus apogon
Senecio diaschides
Senecio hispidulus
Senecio linearifolius
Senecio minimus
Sigesbeckia orientalis
Solanum aviculare
Solanum prinophyllum
Gonocarpus teucrioides
Stellaria flaccida
Stellaria media
Viola hederacea
Wahlenbergia stricta

Community 2: *Eucalyptus campanulata-Eucalyptus saligna* open forest over *Lomandra longifolia*-fern herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus campanulata, Eucalyptus laevopine, Allocasuarina torulosa, Eucalyptus saligna, Caldcluvia paniculosa, Callicoma serratifolia, Tristaniopsis collina, Synoum glandulosum*
- Shrubs *Oxylobium ilicifolium, Persoonia linearis, Indigofera australis*
- Vines *Hibbertia scandens, Glycine clandestina, Clematis aristata*
- Herbs *Lomandra longifolia, Prostanthera incisa, Dianella caerulea*
- Ferns *Calochlaena dubia, Pteridium esculentum*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes).

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):
BARov 21 (*E.campanulata*)
BARus 6 *(Tristianopsis collina-Cryptocarya rigida)*
BARus 8 *(Nothofagus moorei)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*

Hager & Benson (1994)
EF505a *(E.campanulata)*
EF505e *(E.campanulata-E.laevopinea)*

Specht et al. (1995)
158 *(E.campanulata-E.laevopinea-E.cypellocarpa - E.obliqua)*

Distribution

Inside National Park boundaries

Throughout eastern and southern parts of the study area. Particularly common on eastern slopes.

Outside National Park Boundaries

Widespread on the Northern Tablelands, extending to North Coast district on high ridges.

Environmental Correlates

Common on moderately steep slopes from 500–1080 m altitude, in moderately moist and fertile soils mostly derived from low quartz sedimentary rock.

Threats

Exotic Species

Ageratina adenophera, Conyza albida, Verbena rigida.

Fire

Subject to fires from adjacent farm properties.

Information for Fire Management

Average Total Number of Species: 37.95	Species With Known Plant Responses: 48%	Resprouter: Seeder Ratio: 1.10

Known Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Acacia ulicifolia
Adiantum diaphanum
Astrotricha latifolia
Astrotricha longifolia
Banksia integrifolia
Billardiera scandens
Breynia oblongifolia
Cirsium vulgare
Clematis aristata
Desmodium rhytidophyllum
Dichondra repens
Echinopogon ovatus
Galium binifolium
Geranium potentilloides
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Gonocarpus teucrioides
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Leucopogon lanceolatus
Oxylobium ilicifolium
Pandorea pandorana
Pimelea linifolia
Pittosporum undulatum
Poranthera microphylla
Pyrrosia confluens
Pyrrosia rupestris
Senecio diaschides
Senecio hispidulus
Senecio linearifolius
Sigesbeckia orientalis
Stellaria flaccida
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 3: *Eucalyptus saligna-Eucalyptus laevopineaa-Eucalyptus microcorys-Eucalyptus acmenoides* open forest over *Acacia irrorata* shrubland over *Doodia aspera -Oplismenus imbecillus-Lomandra longifolia* herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus laevopinea, Eucalyptus microcorys, Eucalyptus saligna, Doryphora sassafras, Backhousia myrtifolia, Eucalyptus acmenoides, Waterhousea floribunda, Synoum glandulosum, Allocasuarina torulosa*
- Shrubs *Acacia irrorata, Citriobatus pauciflorus, Rapanea howittiana*

- Vines *Desmodium varians, Glycine clandestina, Hibbertia scandens, Smilax australis, Clematis aristata, Geitonoplesium cymosum, Viola hederacea, Cissus hypoglauca, Eustrephus latifolius, Pandorea pandorana, Rubus rosifolius*
- Herbs *Dianella caerulea, Lomandra longifolia, Austrocynoglossum latifolium, Gymnostachys anceps, Urtica incisa, Senecio amygdalifolius, Carex longebrachiata*
- Grasses *Oplismenus imbecillis, Poa labillardieri*
- Ferns *Doodia aspera, Pteridium esculentum, Pellaea falcata, Hypolepis glandulifera, Calochlaena dubia*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes).

Equivalent Vegetation Types

This Community has elements of the following types:

Binns (1996):

BARov 3 (Waterhousia floribunda)
BARov 5 *(Backhousia myrtifolia-Tristianopsis laurina)*
BARov 11.1 *(E.acmenoides-Allocasuarina torulosa)*
BARov 17.1 *(E.laevopinea)*
BARus 2 *(Waterhousia floribunda)*
BARus 5 *(Backhousia myrtifolia)*
BARus 16 *(Acacia irrorata-Doodia aspera)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*

Hager & Benson (1994)

EF479a *(E.laevopinea)*
EF505e *(E.campanulata)*
EF011e *(E.saligna-E.laevopinea)*
EF479f *(E.laevopinea-E.microcorys)*
RF 208 *(Backhousia myrtifolia-Lophostemon confertus-Tristianopsis laurina)*
RF205 *(Waterhousia floribunda-Tristianopsis laurina)*

Specht et al. (1995)

104 *(Choricarpia leptopetala-Backhousia myrtifolia)*

200 (*E.acmenoides-E.pilularis-E.microcorys- Syncarpia glomulifera)*

Distribution

Inside National Park boundaries

Not common. Occurs on eastern and western slopes, with *E.laevopinea, E.saligna, Lomandra longifolia* common in the west, and *E.microcorys, Backhousia myrtifolia, Waterhousia floribunda, Doodia aspera* more common in the east.

Outside National Park Boundaries

Widespread, but not extensive. Located primarily in riparian zones.

Environmental Correlates

Occurs at lower latitudes (240–760 m), in warm and moderately moist and rugged locations in riparian zones.

Threats

Exotic Species

Ageratina riparia, Lantana camara

Fire

Due to the small areas covered by this community, it is subject to local extinction through fires, particularly if repeated. The moist conditions in which this community occurs, however, suggest that fires do not progress rapidly and are likely to be uncommon.

Information for Fire Management

Average Total Number of Species: 56.53	Species With Known Plant Responses: 38%	Resprouter: Seeder Ratio: 1.09

Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Asplenium australasicum
Astrotricha latifolia
Banksia integrifolia
Billardiera scandens
Breynia oblongifolia
Cirsium vulgare
Clematis aristata
Crassula sieberiana
Daucus glochidiatus
Davallia pyxidata
Dichondra repens
Dictymia brownii
Echinopogon ovatus
Galium binifolium
Glycine clandestina
Gnaphalium gymnocephalum
Gnaphalium involucratum
Gonocarpus tetragynus
Goodenia ovata
Gratiola peruviana
Hakea eriantha
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Hypolepis glandulifera
Indigofera australis
Lagenifera stipitata
Omalanthus populifolius
Pandorea pandorana
Pittosporum undulatum
Poranthera microphylla
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Senecio hispidulus
Senecio linearifolius
Senecio madagascariensis
Senecio minimus
Sigesbeckia orientalis
Solanum aviculare
Solanum prinophyllum
Stellaria flaccida
Veronica notabilis
Viola hederacea

Community 4: *Lepidosperma laterale* — mixed species shrubland (occasionally some trees)

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus cypellocarpa, Eucalyptus macrorhyncha* (not in National Park), *Eucalyptus acmenoides*
- Shrubs *Grevillea granulifera* (not in National Park), *Pomaderris helianthemifolia, Westringia eremicola, Acacia irrorata, Gonocarpus oreophilus, Micrantheum hexandrum, Ozothamnus diosmifolius, Pomaderris argyrophylla, Zieria smithii, Correa reflexa, Leptospermum variabile*
- Herbs *Lepidosperma laterale, Carex breviculmis, Hypericum gramineum*
- Grasses *Entolasia stricta, Imperata cylindrica var major*
- Ferns *Cheilanthes sieberi*

Rare and Endangered Species

Grevillea granulifera (not in National Park)

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes). Very closely related to Vegetation Community 5.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARus 11 (*Ozothamnus diosmifolius-Gonocarpus oreophilus*)
BARus 20 *(Leptospermum variabile-Pomaderris argyrophylla)*
BARus 22 *(Pomaderris helianthemifolia-Westringia eremicola)*

Hager & Benson (1994)

EF418a *(E.cypellocarpa)*
Specht et al. (1995)
285 *(E.cypellocarpa-E.obliqua-E.radiata)*
290 *(E.fastigata-E.viminalis-E.obliqua-E.cypellocarpa)*

Distribution

Inside National Park boundaries

Rare, on eastern (e.g. Karuah River) and western (Moonan Brook, Carrow Brook) slopes.

Outside National Park Boundaries

Occurs more extensively on the slopes north-west of the National Park boundaries, but only in small patches.

Environmental Correlates

Occurs on relatively dry, rocky, infertile, and rugged sites away from basic igneous rock (tertiary basalt) at altitudes from 630–1130 m.

Threats

Exotic Species

None

Fire

Due to the small areas covered by this community, it is subject to local extinction through fires, particularly if repeated. The rocky substrate on which this community occurs, however, suggest that fires do not progress well.

Information for Fire Management

Average Total Number of Species: 28.80
Species With Known Plant Responses: 51%
Resprouter: Seeder Ratio: 1.47

Seeder Species (including exotics)

Acacia melanoxylon
Acacia ulicifolia
Banksia integrifolia
Clematis aristata
Comesperma volubile
Crassula sieberiana
Dichondra repens
Galium binifolium
Glycine clandestina
Gnaphalium gymnocephalum
Hibbertia acicularis
Hydrocotyle laxiflora
Hypericum gramineum
Lagenifera stipitata
Monotoca scoparia
Opercularia aspera
Oxylobium ilicifolium
Phyllanthus gunnii
Pittosporum undulatum
Poranthera microphylla
Pyrrosia rupestris
Solanum prinophyllum
Solanum pungetium

Community 5: *Eucalyptus nobilis* — mixed sedgeland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus nobilis*
- Vines *Rubus parvifolius*
- Herbs *Acaena novae-zelandiae, Carex appressa, Geranium potentilloides, Hydrocotyle peduncularis, Lomandra longifolia, Prunella vulgaris, Carex inversa, Carex lobolepis, Cirsium vulgare, Cyperus lucidus, Gratiola peruviana, Haloragis heterophylla, Juncus pauciflorus, Juncus sarophorus, Pratia purpurascens, Ranunculus plebeius, Rumex brownii, Schoenus apogon,*

Trifolium repens, Urtica incisa, Carex longebrachiata, Juncus alexandri, Hydrocotyle peduncularis, Bulbine bulbosa, Carex fascicularis, Carex appressa

- Grasses *Poa labillardieri, Imperata cylindrica*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–6 (*Eucalyptus* spp. forest of lower altitudes). Very closely related to Vegetation Community 4.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARus 13 (*Lomandra longifolia-Juncus alexandri*)

Hager & Benson (1994)

EF479d (E.*laevopinea-E.nobilis*)
Specht et al. (1995)
No equivalent

Distribution

Inside National Park boundaries

Rare, in small areas in Mount Cockrow area.

Outside National Park Boundaries

Locally abundant on fertile loamy soils on the eastern slopes of the Northern Tablelands.

Environmental Correlates

Occurs on fertile, moist, moderately steep sites, mostly on soils derived from basic igneous rock.

Threats

Exotic Species

Holcus lanatus, Sonchus asper spp glaucescens, Verbena bonariensis, V.officinalis.

Fire

Due to the small areas covered by this community, it is subject to local extinction through fires, particularly if repeated.

Information for Fire Management

Average Total Number of Species: 35.00	Species With Known Plant Responses: 28%	Resprouter: Seeder Ratio: 0.71

Seeder Species (including exotics)

Acacia melanoxylon
Asperula scoparia
Banksia integrifolia
Cirsium vulgare
Gnaphalium gymnocephalum
Gnaphalium involucratum
Gratiola peruviana
Hypolepis glandulifera
Schoenus apogon
Senecio minimus
Viola hederacea

Community 6: Eucalyptus canaliculata -Eucalyptus acmenoides -Eucalyptus saligna open forest over Imperata cylindrica-Poa labillardieri grassland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus acmenoides, Eucalyptus saligna, Eucalyptus canaliculata, Allocasuarina torulosa, Eucalyptus campanulata, Syncarpia glomulifera, Eucalyptus carnea, Eucalyptus laevopinea*
- Shrubs *Acacia irrorata, Swainsona galegifolia, Breynia oblongifolia, Persoonia linearis, Psychotria loniceroides*
- Vines *Desmodium varians, Dianella caerulea, Rubus parvifolius, Hardenbergia violacea, Clematis aristata, Cissus antarctica, Hibbertia scandens*
- Herbs *Glycine clandestina, Sigesbeckia orientalis, Dichondra repens, Lomandra longifolia, Pratia purpurascens*
- Grasses *Imperata cylindrica, Poa labillardieri, Plectranthus parviflorus, Themeda australis*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 1–5 (*Eucalyptus* spp. forest of lower altitudes).

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 13.1 (E.carnea-Allocasuarina torulosa)
BARov 13.2 *(E.carnea-E.maculata)*
BARov 14 *(A.torulosa-E.tereticornis-E.eugenioides)*
BARov 15 *(E.melliodora-E.eugenioides-E.tereticornis)*
BARov 21 *(E.campanulata)*
BARus 17 *(Imperata cylindrica-Desmodium varians)*

Hager & Benson (1994)

EF095a *(E.acmenoides)*
EF095d *(E.acmenoides-E.tereticornis-A.torulosa)*
EF077b *(E.canaliculata-E.eugenioides-A.torulosa)*

Specht et al. (1995)

No equivalent

Distribution

Inside National Park boundaries

Widespread in an arc along the southern edge of the study area.

Outside National Park Boundaries

Elements of this community occur along the North and Central Coast regions at altitudes over 300 m.

Environmental Correlates

Occurs on lower slopes (140–600 m) in warm but dry sites on soils with low fertility derived mostly from low quartz sedimentary rock.

Threats

Exotic Species

Ageratina adenophora, Bidens pilosa, Centaurium erythraea, Centella asiatica, Conyza albida, Conyza bonariensis, Lantana camara, Passiflora subpeltata, Setaria pumila, Solanum nigrum, Sporobolus pyramidalis, Taraxacum officinale, Verbena bonariensis

Fire

Subject to fires from adjacent farm properties.

Information for Fire Management

Average Total Number of Species: 51.84
Species With Known Plant Responses:43 %
Resprouter: Seeder Ratio: 1.28

Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Acacia obtusifolia
Acacia ulicifolia
Anagallis arvensis
Arthropteris tenella
Astrotricha latifolia
Billardiera scandens
Breynia oblongifolia
Callitris macleayana
Centaurium erythraea
Cirsium vulgare
Clematis aristata
Convolvulus erubescens
Conyza bonariensis
Crassula sieberiana
Daucus glochidiatus
Davallia pyxidata
Desmodium rhytidophyllum
Dichondra repens
Dichopogon strictus
Echinopogon ovatus
Galium gaudichaudii
Geranium potentilloides
Geranium solanderi
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Gonocarpus teucrioides
Helichrysum bracteatum
Hibbertia aspera
Hibbertia linearis
Hibbertia scandens
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Indigofera australis
Kennedia rubicunda
Lagenifera stipitata
Opercularia aspera
Opercularia diphylla
Oxylobium ilicifolium
Pandorea pandorana
Pittosporum undulatum
Poranthera microphylla
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Scaevola albida
Schoenus apogon
Senecio diaschides
Senecio lautus
Senecio linearifolius
Senecio madagascariensis
Sigesbeckia orientalis
Solanum nigrum
Solanum prinophyllum
Solanum pungetium
Sonchus oleraceus
Stackhousia viminea
Stellaria flaccida
Tricoryne elatior
Viola hederacea
Wahlenbergia stricta

Community 7: Rain Forest (Eucalyptus species absent)

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Pennantia cunninghamii, Daphnandra species A, Diploglottis australis, Doryphora sassafras, Dysoxylum fraserianum, Acmena smithii, Alectryon subcinereus, Caldcluvia paniculosa, Neolitsea dealbata, Polyosma cunninghamii, Dendrocnide excelsa, Diospyros australis, Syzygium australe, Baloghia inophylla, Acradenia euodiiformis, Schizomeria ovata, Orites excelsa, Sloanea woollsii*
- Shrubs *Citriobatus pauciflorus, Eupomatia laurina, Tasmannia insipida*
- Vines *Cissus antarctica, Morinda jasminoides, Palmeria scandens, Pandorea pandorana, Cissus hypoglauca, Parsonsia straminea*
- Herbs *Lomandra spicata, Gymnostachys anceps, Sarcochilus falcatus*
- Ferns *Arthropteris tenella, Asplenium australasicum, Adiantum formosum, Microsorum scandens, Pyrrosia confluens, Lastreopsis microsora, Pteris umbrosa, Lastreopsis decomposita*

Rare and Endangered Species

Daphnandra sp. A

Relationship to Other Communities

Related to Vegetation Community 8 (*Eucalyptus saligna* dominated wet sclerophyll)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 2.1 (*Acradenia eudiiformis)*
BARov 2.2 *(Sloanea woollsii-Pennantia cunninghamii)*
BARov 6.1 *(Caldcluvia paniculosa-Doryphora sassafras-Schizomeria* ovata)
BARov 6.2 *(Sloanea woollsia-Doryphora sassafras)*
BARov 6.3 *(Sloanea woollsia-Schizomeria ovata-Caldcluvia paniculosa)*
BARov 10.1 *(E.saligna)*
BARus 1 *(Cissus antarctica-Lastreopsis microsora)*
BARus 4 *(Doryphora sassafras)*
BARus 6 *(Tristianopsis collina-Cryptocarya rigida)*
BARus 7 *(Guioa semiglauca-Croton verreauxii)*

Hager & Benson (1994)

RF111 *(Sloanea woolsii-Dysoxylum fraserianum-Heritiera actinophylla-Caldcluvia paniculata)*
RF112 *Schizomeria ovata-Doryphora sassafras-Caldcluvia paniculata-Cryptocarya glaucescens*
RF113 *(Doryphora sassafras-Daphnandra micrantha -Dendrocnide excelsa-Ficus spp.–Toona australis)*

Floyd (1990)

A III 12 (=RF111 of Hager & Benson1994)
A III 13 (=RF112 of Hager & Benson1994)
A III 12 (=RF113 of Hager & Benson1994)
B X 39 *(Schizomeria-Doryphora-Caldcluvia-Orites)*

Distribution

Inside National Park boundaries

Throughout southern parts of the study area.

Outside National Park Boundaries

Not investigated

Environmental Correlates

Occurs in relatively warm sites on lower slopes and in riparian zones on soils with low fertility, derived primarily from low quartz sedimentary rock.

Threats

Exotic Species

Ageratina adenophora, A.riparia, Phytolacca octandra

Fire

Sensitive to fire. However, given the moist conditions in which this community is found, it is unlikely that fire poses a threat, except at the edges.

Information for Fire Management

Average Total Number of Species:	Species With Known Plant Responses:	Resprouter: Seeder Ratio:
51.04	19%	0.96

Seeder Species (including exotics)

Acacia melanoxylon
Adiantum diaphanum
Arthropteris tenella
Asplenium australasicum
Astrotricha latifolia
Breynia oblongifolia
Clematis aristata
Davallia pyxidata
Dictymia brownii
Echinopogon ovatus
Galium binifolium
Glycine clandestina
Gratiola peruviana
Pandorea pandorana
Phytolacca octandra
Pittosporum undulatum
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Solanum aviculare
Solanum prinophyllum
Solanum pungetium
Viola hederacea

Community 8: *Eucalyptus saligna* open forest over rainforest understorey

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Synoum glandulosum, Eucalyptus saligna, Acmena smithii, Caldcluvia paniculosa, Cryptocarya glaucescens, Diospyros australis, Schizomeria ovata, Tristaniopsis collina, Daphnandra species A, Cryptocarya rigida, Elaeocarpus reticulatus, Rapanea variabilis, Rhodamnia rubescens, Dysoxylum fraserianum, Guioa semiglauca, Eucalyptus campanulata, Endiandra sieberi, Acacia melanoxylon, Neolitsea australiensis, Cryptocarya meissneriana*
- Shrubs *Citriobatus pauciflorus, Tasmannia insipida, Eupomatia laurina, Psychotria loniceroides, Trochocarpa laurina, Archirhodomyrtus beckleri*
- Vines *Smilax australis, Parsonsia straminea, Cephalaralia cephalobotrys, Cissus antarctica, Dioscorea transversa, Cissus hypoglauca, Geitonoplesium cymosum, Palmeria scandens*
- Herbs *Gymnostachys anceps, Sarcochilus falcatus*
- Ferns *Blechnum cartilagineum, Pyrrosia rupestris*

Rare and Endangered Species

None

Relationship to Other Communities

Related to Vegetation Community 7 (rain forest)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 10.1 *(E. saligna)*
BARov 21 *(E. campanulata)*
BARus 6 *(Tristianopsis collina-Cryptocarya rigida)*
BARus 8 *(Nothofagus moorei)*
Hager & Benson (1994)
EF011a *(E. saligna)*
EF011c *(E. saligna-E. laevopinea)*
EF011e *(E. saligna-E. quadrangulata)*

Specht et al. (1995)

159 *(E. saligna-E. microcorys)*

Distribution

Inside National Park boundaries

Throughout the southern parts of the study area. Particularly common in the Whispering Gully area

Outside National Park Boundaries

Occurs along the coastal and escarpment zones northward from the central South Coast.

Environmental Correlates

Occurs in warm, riparian, and other moist locations, on relatively steep slopes and in gullies with moderately fertile soils mostly derived from low quartzose sedimentary rock.

Threats

Exotic Species

None

Fire

Many species within this community are sensitive to fire. Episodic fires are, however, required for the maintenance of this community.

Information for Fire Management

Average Total Number of Species: 49.22	Species With Known Plant Responses: 26%	Resprouter: Seeder Ratio: 1.49

Known Seeder Species (including exotics)

Acacia maidenii
Acacia melanoxylon
Adiantum diaphanum
Arthropteris tenella
Asplenium australasicum
Astrotricha latifolia
Banksia integrifolia
Breynia oblongifolia
Callitris macleayana
Cirsium vulgare
Clematis aristata
Davallia pyxidata
Dictymia brownii
Gonocarpus teucrioides
Hibbertia scandens
Hydrocotyle laxiflora
Hypolepis glandulifera
Pandorea pandorana
Pittosporum undulatum
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Sigesbeckia orientalis
Solanum aviculare
Solanum prinophyllum
Veronica notabilis
Viola hederacea

Community 9: *Eucalyptus fastigata-Eucalyptus obliqua-Eucalyptus dalrympleana-Eucalyptus laevopinea-Eucalyptus pauciflora* open forest over *Poa sieberiana* grassland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus fastigata, Eucalyptus obliqua, Eucalyptus dalrympleana, Eucalyptus laevopinea, Eucalyptus pauciflora, Acacia melanoxylon, Eucalyptus nobilis, Eucalyptus dalrympleana ssp heptantha*
- Shrubs *Leucopogon hookeri, Acacia dealbata, Coprosma quadrifida*
- Vines *Glycine clandestina, Clematis aristata, Rubus parvifolius, Smilax australis*
- Herbs *Poranthera microphylla, Viola hederacea, Viola betonicifolia, Dichondra repens, Pratia pedunculata, Asperula conferta, Hydrocotyle laxiflora, Oreomyrrhis eriopoda, Brachycome microcarpa, Lomandra longifolia, Hydrocotyle acutiloba, Wahlenbergia ceracea*
- Grasses *Poa sieberiana*
- Ferns *Pteridium esculentum*

Rare and Endangered Species

Acacia barringtonensis, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Community 10–13 (*Eucalyptus* spp. forest of higher altitudes)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 18 (E.obliqua)
BARov 19.1 *(E.fastigata)*
BARov 20 *(E.nobilis)*
BARov 21 *(E.campanulata)*
BARov 22 *(E.dalrympleana-E.pauciflora)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*

Hager & Benson (1994)

EF475a *(E.obliqua)*
EF475e*(E.obliqua-E.fastigata)*
EF477a *(E.fastigata)*
EF477c*(E.fastigata-E.nobilis)*
EF414a *(E.nobilis)*
EF413a *(E.dalrympleana)*
EF411a *(E.pauciflora)*

Specht et al. (1995)

290 *(E. fastigat-E. viminalis-E. obliqua-E. cypellocarpa)*

Distribution

Inside National Park boundaries

Common on the plateaux. Extensive north of the study area.

Outside National Park Boundaries

Found primarily on the eastern side of the Tablelands, in moist locations.

Environmental Correlates

Occurs in moderately flat situations between 840–1500 m altitude on soils of moderate fertility.

Threats

Exotic Species

Centaurium tenuiflorum, Conyza albida, Cytisus scoparius var. scoparius, Lotus corniculatus, Sonchus asper spp. glaucescens, Taraxacum officinale

Fire

Subject to wild fires from the west during late winter in dry years

Information for Fire Management

Average Total Number of Species: 42.77	Species With Known Plant Responses: 49%	Resprouter: Seeder Ratio: 0.77

Known Seeder Species (including exotics)

Acacia dealbata
Acacia maidenii
Acacia melanoxylon
Acacia ulicifolia
Adiantum diaphanum
Arrhenechthites mixta
Asperula scoparia
Banksia integrifolia
Billardiera scandens
Cerastium glomeratum
Cirsium vulgare
Clematis aristata
Coprosma nitida
Crassula sieberiana
Dichondra repens
Echinopogon ovatus
Galium binifolium
Galium gaudichaudii
Geranium potentilloides
Geranium solanderi
Glycine clandestina
Gnaphalium gymnocephalum
Gnaphalium involucratum
Gonocarpus tetragynus
Gonocarpus teucrioides
Gratiola peruviana
Hakea eriantha
Helichrysum apiculatum
Helichrysum bracteatum
Helichrysum dendroideum
Hibbertia scandens
Hybanthus monopetalus
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Indigofera australis
Lagenifera stipitata
Leucopogon lanceolatus
Lobelia gibbosa
Olearia phlogopappa
Oxylobium ilicifolium
Pandorea pandorana
Poranthera microphylla
Prostanthera lasianthos
Pyrrosia confluens
Pyrrosia rupestris
Schoenus apogon
Senecio diaschides
Senecio hispidulus
Senecio lautus
Senecio linearifolius
Senecio minimus
Sigesbeckia orientalis
Solanum prinophyllum
Stellaria flaccida
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 10: *Eucalyptus stellulata* open forest over *Cytisus scoparius* var. *scoparius* shrubland over *Poa sieberiana* grassland

Description

20 Species With Highest Mean Cover and/or Species Common to > 50% of Plots

- Trees *Eucalyptus stellulata, Eucalyptus pauciflora*
- Shrubs *Cytisus scoparius, Hakea microcarpa, Leucopogon hookeri, Epacris breviflora, Tasmannia purpurascens, Hakea microcarpa*
- Herbs *Acaena novae-zelandiae, Viola hederacea, Oreomyrrhis eriopoda, Trifolium repens, Dichondra repens, Senecio lautus, Chiloglottis pluricallata, Asperula gunnii, Empodisma minus*
- Grasses *Poa sieberiana, Poa labillardieri*

Rare and Endangered Species

Asperula asthenes, Euphrasia ciliolata, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Communities 9–13 (*Eucalyptus* spp. forest of higher altitudes)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

No equivalent

Hager & Benson (1994)

EF411b *(E.pauciflora-E.stellulata)*

Specht et al. (1995)

247 *(E.paucifflora-E.stellulata-E.camphora)*

Distribution

Inside National Park boundaries

Restricted to riparian zones and edges of sub-alpine swamps on plateaux

Outside National Park Boundaries

Throughout cold and frosty sites on the Tablelands.

Environmental Correlates

Occurs on cold, flat, and damp sites at high altitudes (1430-1500 m), on fertile soils derived primarily from basic igneous rock

Threats

Exotic Species

Cytisus scoparius

Fire

Subject to wild fires from the west during late winter in dry years

Information for Fire Management

Average Total Number of Species: 26.83	Species With Known Plant Responses: 25%	Resprouter: Seeder Ratio: 1.05

Known Seeder Species (including exotics)

Acacia dealbata
Acacia melanoxylon
Cerastium semidecandrum
Cirsium vulgare
Clematis aristata
Dichondra repens
Geranium solanderi
Gnaphalium involucratum
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Pimelea linifoli
Poranthera microphylla
Viola hederacea
Wahlenbergia stricta

Community 11: *Eucalyptus pauciflora* open forest over *Tasmannia purpurescens* shrubland over mixed herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus pauciflora, Elaeocarpus holopetalus, Eucalyptus dalrympleana, Eucalyptus viminalis*
- Shrubs *Acacia melanoxylon, Tasmannia purpurascens, Leucopogon hookeri, Coprosma nitida, Olearia oppositifolia, Acacia dealbata, Elaeocarpus holopetalus, Leptospermum polygalifolium, Callistemon pallidus,*
- Vines *Smilax australis*
- Herbs *Viola hederacea, Hydrocotyle laxiflora, Pratia pedunculata, Asperula gunnii, Stellaria flaccida, Gaultheria appressa*
- Grasses *Poa sieberiana*
- Ferns *Polystichum proliferum, Dicksonia antarctica*

Rare and Endangered Species

Acacia barringtonensis, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Communities 9–13 (*Eucalyptus* spp. forest of higher altitudes). Closely related to Vegetation Community 12, which tends to occur adjacent to it.

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 9 (*Elaeocarpus holopetalus-Atherosperma moschatum-Leptospermum polygalifolium)*
BARov 19.2 *(Acacia dealbata-E.fastigata)*
BARus 10 *(Acacia dealbata-Prostanthera lasianthos)*
BARus 12 *(Leptospermum polygalifolium-Elaeocarpus holopetalus)*

Hager & Benson (1994)

EF411c *(E. pauciflora-E. dalrympleana)*
EF411d *(E. pauciflora-E. viminalis)*
RF 410 *(Elaeocarpus holopetalus)*

Specht et al. (1995)

237 *(E.delegatensis-E.pauciflora-E.rodwayi)*
242 *(E.pauciflora-E.rubida)*
251 *(E.nova-anglica-E.pauciflora-E.dalrympleana)*

Distribution

Inside National Park boundaries

Restricted to riparian/moist zones in highest parts of the Barrington Tops plateau.

Outside National Park Boundaries

Occurs throughout the Tablelands region.

Environmental Correlates

Occurs on cold, flat, and damp sites at high altitudes (1310-1540 m), on fertile soils almost always derived from basic igneous rock

Threats

Exotic Species

None

Fire

Subject to wild fires from the west during late winter in dry years

Information for Fire Management

Average Total Number of Species: 35.57	Species With Known Plant Responses: 39%	Resprouter: Seeder Ratio: 0.87

Seeder Species (including exotics)

Acacia dealbata
Acacia melanoxylon
Clematis aristata
Coprosma nitida
Echinopogon ovatus
Galium gaudichaudii
Geranium potentilloides
Lagenifera stipitata
Olearia phlogopappa
Poranthera microphylla
Prostanthera lasianthos
Pyrrosia rupestris
Senecio velleioides
Stellaria flaccida

Gonocarpus teucrioides
Gratiola peruviana
Hydrocotyle laxiflora
Hypericum gramineum
Stellaria media
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 12: Sedgeland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus pauciflora, Eucalyptus dalrympleana*
- Shrubs *Leptospermum argenteum, Epacris* Unknown, *Cytisus scoparius, Baeckea utilis, Persoonia chamaepeuce, Hakea microcarpa*
- Herbs *Restio stenocoleus, Empodisma minus, Lomandra longifolia, Carex gaudichaudiana, Eleocharis sphacelata, Isolepis habra, Scirpus polystachyus, Hypericum gramineum, Acaena novae-zelandiae, Hypochoeris radicata, Ranunculus pimpinellifolius*
- Grasses *Poa costiniana, Poa sieberiana, Deyeuxia gunniana*

Rare and Endangered Species

Acacia barringtonensis, Plantago cladarophylla, Tasmannia glaucifolia, Tasmannia purpurascens

Relationship to Other Communities

Related to Vegetation Community 9–13 (*Eucalyptus* spp. forest of higher altitudes). Closely related to Vegetation Community 11, which tends to occur adjacent to it

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 17.1 (E.laevopinea)
BARov 18 *(E.obliqua)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*
BARus 23 *(Restio stenocoleus-Leptospermum argenteum)*

Hager & Benson (1994)

EF411c *(E.pauciflora-E.dalrympleana)*

Specht et al. (1995)

No equivalent

Distribution

Inside National Park boundaries

Restricted to wetlands on the plateaux

Outside National Park Boundaries

Occurs throughout frost flats in the Tableland region

Environmental Correlates

Occurs on cold, flat, damp, partially inundated sites at high altitudes (1200–1460 m), on fertile soils often derived from basic igneous rock

Threats

Exotic Species

Cytisus scoparius var. *scoparius*

Fire

Subject to wild fires from the west during late winter in dry years, though hindered by the wet conditions of this vegetation community

Information for Fire Management

Average Total Number of Species: 32.00	Species With Known Plant Responses: 32%	Resprouter: Seeder Ratio: 0.84

Known Seeder Species (including exotics)

Acacia melanoxylon
Comesperma ericinum
Dichondra repens
Gnaphalium gymnocephalum
Gonocarpus micranthus
Gonocarpus teucrioides
Gratiola peruviana
Helichrysum dendroideum
Hybanthus monopetalus
Hydrocotyle laxiflora
Hypericum gramineum
Hypochaeris radicata
Leucopogon lanceolatus
Monotoca scoparia
Olearia phlogopappa
Pimelea linifolia
Poranthera microphylla
Prostanthera lasianthos
Schoenus apogon
Senecio lautus
Stellaria flaccida
Utricularia dichotoma
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 13: *Eucalyptus obliqua* open forest over *Poa sieberiana* — mixed ferns herbland

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Eucalyptus obliqua, Eucalyptus fastigata, Eucalyptus campanulata*
- Shrubs *Coprosma quadrifida, Banksia integrifolia, Tasmannia stipitata, Acacia dealbata, Leucopogon lanceolatus, Astrotricha latifolia, Acacia elata*
- Vines *Smilax australis, Clematis aristata*
- Herbs *Lomandra longifolia, Hydrocotyle laxiflora, Dianella caerulea, Lepidosperma laterale, Viola hederacea*
- Grasses *Poa sieberiana, Microlaena stipoides*

- Ferns *Sticherus lobatus, Blechnum wattsii, Polystichum proliferum, Calochlaena dubia, Cyathea australis, Pteridium esculentum*

Rare and Endangered Species

Tasmannia purpurascens, Acacia barringtonensis

Relationship to Other Communities

Related to Vegetation Communities 10–13 (*Eucalyptus* spp. forest of higher altitudes)

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 18 (E.obliqua)
BARov 19.1 *(E.fastigata)*
BARus 18 *(Poa sieberiana-Desmodium varians)*
BARus 19 *(Poa sieberiana-Lomandra longifolia)*
Hager & Benson (1994)
EF475a *(E.obliqua)*
EF475e *(E.obliqua-E.fastigata)*
EF425f *(E.obliqua-E.campanulata)*

Specht et al. (1995)

290 *(E.fastigat-E.viminalis-E.obliqua-E.cypellocarpa)*
158 *(E.campanulata-E.laevopinea-E.cypellocarpa-E.obliqua)*

Distribution

Inside National Park boundaries

Common at higher altitudes in central and northern parts of the study area

Outside National Park Boundaries

Found throughout the Central and Southern New England Tableland bioregion above 600-900 m.

Environmental Correlates

Occurs on moderately steep slopes from 1000 - 1380 m altitude, on soils of medium fertility derived primarily from low quartzose sedimentary rock.

Threats

Exotic Species

Conyza albida, Holcus lanatus

Fire

Not threatened by fire

Information for Fire Management

Average Total Number of Species: 35.88
Species With Known Plant Responses: 50%
Resprouter: Seeder Ratio: 0.95

Known Seeder Species (including exotics)

Acacia dealbata
Acacia melanoxylon
Acacia obtusifolia
Acacia ulicifolia
Asperula scoparia
Astrotricha latifolia
Banksia integrifolia
Billardiera scandens
Cirsium vulgare
Clematis aristata
Coprosma nitida
Dichondra repens
Echinopogon ovatus
Galium binifolium
Geranium potentilloides
Geranium solanderi
Glycine clandestina
Gnaphalium gymnocephalum
Gonocarpus tetragynus
Gonocarpus teucrioides
Goodenia ovata
Hakea eriantha
Helichrysum bracteatum
Hibbertia scandens
Hydrocotyle laxiflora
Lagenifera stipitata
Leucopogon lanceolatus
Monotoca scoparia
Oxylobium ilicifolium
Pandorea pandorana
Poranthera microphylla
Prostanthera lasianthos
Pyrrosia confluens
Pyrrosia rupestris
Rapanea howittiana
Senecio diaschides
Senecio linearifolius
Senecio minimus
Sigesbeckia orientalis
Solanum aviculare
Stellaria flaccida
Veronica notabilis
Viola hederacea
Wahlenbergia stricta

Community 14: *Nothofagus moorei* closed forest

Description

20 Species With Highest Mean Cover and/or Species Common To > 50% of Plots

- Trees *Nothofagus moorei, Doryphora sassafras, Eucalyptus fastigata, Schizomeria ovata, Caldcluvia paniculosa, Quintinia sieberi, Elaeocarpus holopetalus, Eucalyptus obliqua, Callicoma serratifolia, Eucalyptus dalrympleana,*
- Shrubs *Acacia elata, Trochocarpa sp. nov., Coprosma quadrifida*
- Vines *Smilax australis, Parsonsia brownii, Clematis aristata*
- Herbs *Prostanthera lasianthos, Veronica notabilis*
- Ferns *Dicksonia antarctica, Blechnum wattsii, Blechnum cartilagineum, Pyrrosia rupestris*

Rare and Endangered Species

Tasmannia purpurascens

Relationship to Other Communities

Most distinctive Vegetation Community of all communities delineated. Usually adjacent to any of Vegetation Communities 9–13, 7 or 8

Equivalent Vegetation Types

This Vegetation Community contains elements of the following types:

Binns (1996):

BARov 8 (Nothofagus moorei-Doryphora sassafras)
BARov 18 *(E.obliqua)*
BARus 8 *(Nothofagus moorei)*

Hager & Benson (1994)

RF 404 *(Nothofagus moorei-Elaeocarpus holopetalus)*
RF403 *(Nothofagus moorei-Doryphora sassafras-Orites excelsa-Caldcluvia paniculata)*

Specht et al. (1995)

38 *(Nothofagus moorei-Cryptocarya foveolata-Orites excelsa)*

Distribution

Inside National Park boundaries

Common on slopes at higher altitudes in central and northern parts of the study area

Outside National Park Boundaries

Found in restricted areas from the Barrington Tops to the Border Ranges.

Environmental Correlates

Occurs slopes or depressions at high altitudes (1040–1380 m), on moderately fertile soils and in moist conditions

Threats

Exotic Species

None

Fire

The edges of stands on the plateau are subject to wild fires in late winter during dry years.

Information for Fire Management

Average Total Number of Species: 22.09	Species With Known Plant Responses: 36%	Resprouter: Seeder Ratio: 1.07

Seeder Species (including exotics)

Acacia dealbata
Acacia melanoxylon
Banksia integrifolia
Clematis aristata
Dichondra repens
Geranium potentilloides
Gonocarpus teucrioides
Gratiola peruviana
Hibbertia scandens
Hydrocotyle laxiflora
Lagenifera stipitata
Leucopogon lanceolatus
Pandorea pandorana
Prostanthera lasianthos
Pyrrosia rupestris
Schoenus apogon
Stellaria flaccida
Veronica notabilis
Viola hederacea

Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation

Lynette C. McLoughlin

McLoughlin, L.C. (Graduate School of the Environment, Macquarie University, NSW Australia, 2109) 2000. Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation. Cunninghamia *6(3): 579–610.* This study examined a variety of written, cartographic and pictorial historical materials to document the extent and distribution of inter-tidal wetlands and riparian vegetation along the Parramatta River and its bays from 1788 (first settlement in Port Jackson) to c. 1940 (when documentation by aerial photographs commenced). Although data available do not permit detailed quantitative analysis, and no single source is definitive, in total they yield a more detailed picture has hitherto been available. These historical sources indicate that in the 19th century extensive mudflats and saltmarsh communities dominated the inter-tidal zone, with mangroves more limited to creek fringes and some patches in bays for much of the period. In the upper river from Subiaco Creek to Parramatta, there is no evidence for the presence of mangroves until the 1870s. Following settlement and increased sedimentation, inter-tidal mudflats expanded, mangroves colonised up river and out onto mudflats in bays in the latter part of the 19th century, followed by expansion into saltmarsh in the 20th century.

This study demonstrates that some of the assumptions regarding the former extent of mangroves on which recent studies and foreshore plans are based are inappropriate. The historical data, combined with subsequent aerial photographic data, provides an enlarged database that needs to be taken into account in the formulation of conservation management plans and restoration strategies.

Keywords: foreshore vegetation, mangrove colonisation, saltmarsh, reclamation, revegetation, wetland zonation, wetland conservation, Australia, Sydney Harbour

Introduction

Over much of the period from European settlement in 1788, Sydney Harbour and Parramatta River were viewed from a utilitarian perspective. However, from the 1970s, as waterfront industries and port activities relocated and shipbuilding declined, changes in land use led to a greater appreciation of the waterways' aesthetic and recreational values. With the Clean Waters Act in 1970 and early measures to improve the river's water quality, interest in the ecological values of the Parramatta River and its foreshores also emerged. The National Trust of Australia (NSW) published *Parameters for the River* (Lynch et al. 1976) to stimulate such interest in improving degraded aspects of the river: its foreshores, landscapes, remnant vegetation, habitats and fauna.

Improvement has included protection and conservation of a number of vegetation remnants, particularly wetlands, while the restoration of indigenous vegetation along foreshores has been included in many planning documents of the 1980s and 1990s. However, wetlands restoration requires an understanding of their former distribution and composition, as do policies and decisions for foreshore vegetation management. Studies have used aerial photographs to document former wetland communities on the Parramatta River and to trace changes in their distribution (Thorogood 1985, DEP 1986b, Moss 1987, Clarke & Benson 1988; Burchett & Pulkownik 1996), but the earliest aerial photographs date from the 1930s and there has been very little work in tracing other, earlier, sources.

This paper examines the source material and evidence available to determine the extent and distribution of inter-tidal wetlands and shoreline vegetation along the Parramatta River arm of the Sydney Harbour system from time of European settlement in 1788, up to 1940. The evidence consists of written descriptions, pictorial evidence such as paintings, drawings and photographs, and cartographic evidence in maps and plans. Each is by nature fragmentary and incomplete in coverage but in total yields a more detailed picture than the assumptions and unsourced statements on which the understandings of recent studies are built. While the primary goal is to shed light on the foreshores at the time of European settlement, this paper will also consider the changes that occurred up to 1940. Implications of a longer-term historical view for planning and conservation are considered following analysis of the historical data.

Study area

Parramatta River commences a short distance up the Sydney Harbour system from Sydney Cove, extending from its junction with the Lane Cove River at Greenwich/Balmain to the weir at Parramatta (see Fig. 1 for all cited locations). The river lies along the southern edge of the Hornsby Plateau, massive vertically jointed Hawkesbury sandstone capped with Wianamatta Group shales, in which the river's northern tributaries have cut deep steep-sided valleys. Sandstone is the surface geology along much of the northern shores of the river and outliers of the sandstone plateau occur on the southern side of the river in decreasing prominence from Balmain to Uhrs Point. On this south side of the river the sandstone is broken by large embayments, where tributary creeks draining catchments substantially of shale built larger patches of alluvium and inter-tidal mudflats.

From Homebush Bay upstream the geology changes dramatically on the southern side. Here the catchment consists entirely of Wianamatta shales, which have a low resistance to denudation processes and result in subdued terrain. High levels of sediment stripped from the shales produced large deposits of alluvium along the river and its tributaries between Homebush Bay and Clay Cliff Creek, and associated inter-tidal mudflats, particularly from Homebush Bay to Duck River.

Much of the shoreline has been disturbed by clearing and reclamation but patches of wetland can be found in a number of locations, notably Homebush Bay, Newington, Duck River, Majors and Yaralla Bays on the south side, and Meadowbank and Ermington on the north (Register of the National Estate n.d. a–g). These wetlands are

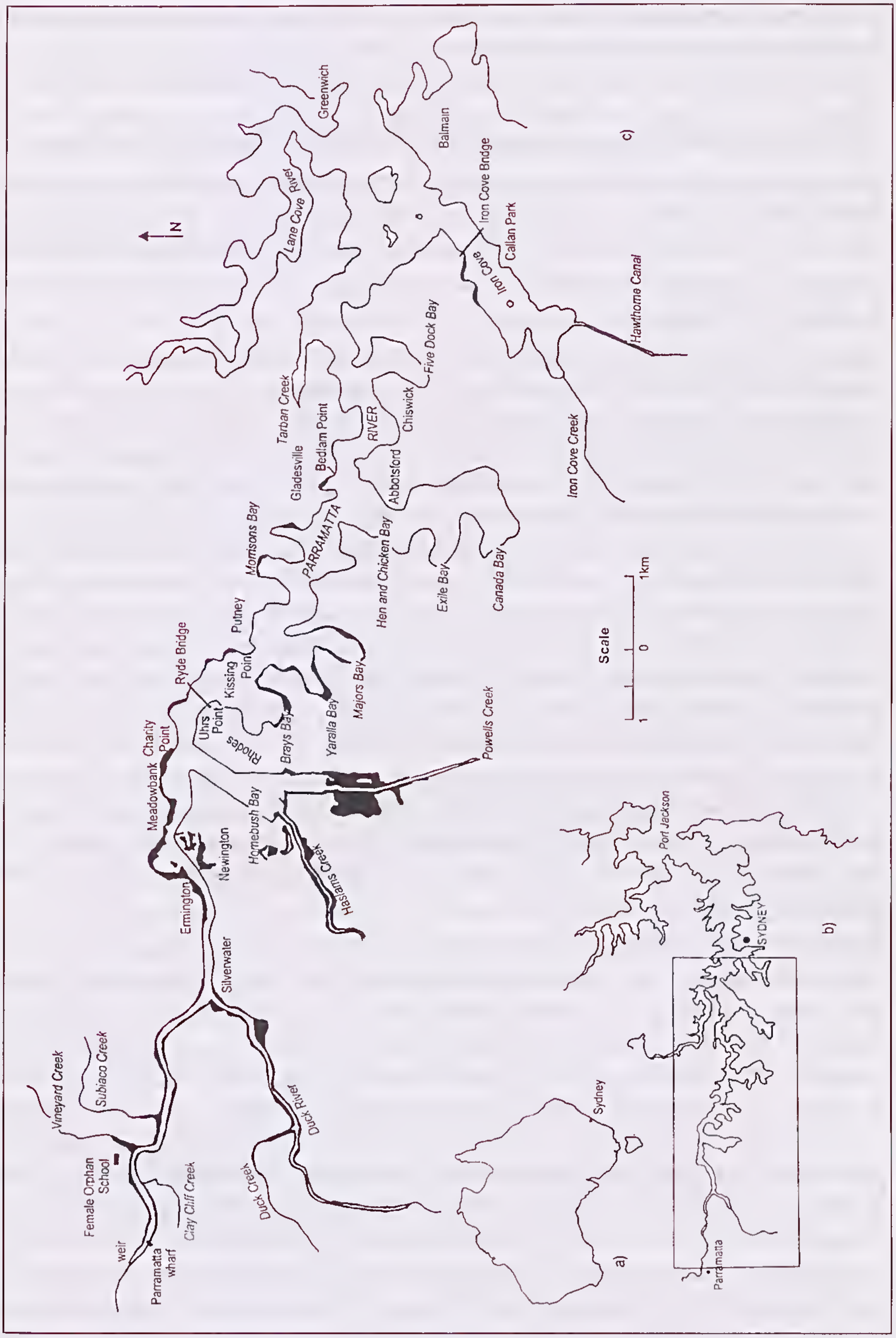


Fig. 1. The Study Area (a) geographic location; (b) the Sydney Harbour system; (c) Parramatta River from Greenwich/Balmain to the weir at Parramatta including: ■ mangrove distribution in the 1990s (from NSW Land Information Centre 1994 aerial photograph series with some later ground confirmation).

predominantly mangroves and mudflats with some small areas of saltmarsh at Homebush Bay and Newington and casuarinas at Newington. There is also a mangrove fringe along many sections of the river above Homebush Bay as far as Parramatta.

Existing reconstructions and perceptions of former wetland distribution

Reconstruction of the historical distribution of Parramatta River inter-tidal wetlands and shoreline vegetation has relied largely on three elements: aerial photographs series dating from the 1930s, ecological inference from present distribution patterns, and some key assumptions which have been repeated through a variety of studies of the past twenty years.

Two of the most pervasive of these assumptions are that the river was lined with mangroves to the limit of tidal influence at Parramatta (except perhaps for rocky headlands) prior to the impact of European development, and that present areas of mangroves are therefore small remnants of this former extent. This gained currency with Lynch et al.'s (1976) statement that 'the mangrove community is recorded to have once extended in a continuous strip for at least 60 kilometres up Parramatta River and in its bays stretching southwards.' This 'recorded' observation is unsourced and undated but forms part of Lynch et al.'s description of the river's former wetlands and foreshore vegetation. The mid-channel length of the Parramatta River is 19 km from the weir at Parramatta to Greenwich. The description, not located by this study, clearly refers to a shoreline distance, but along which parts of the river, whether confined only to the bays on the southern side and whether based on the 1788 shoreline or at some later stage, is not clear. Yet in many subsequent studies of the river and its vegetation, this unsourced description has been reproduced as the only 'evidence' for the river's pre-1940s foreshore vegetation (SPCC 1979, Department of Environment and Planning (DEP) 1986a, 1986c, Moss 1987, Latham 1988, MacDonald 1990, EDAW & Environmental Partnership 1996). Only one of these (DEP 1986a) noted that the original statement was unsourced.

Perceptions of the historical extent of saltmarsh vary. Saltmarsh is taken to include rush, sedge and reed communities as well as herbs and grasses, as defined by Adam et al. (1988) and all rarely distinguished separately in historical sources. According to Hamilton (1919) large areas of saltpan mudflats were also once found in or adjacent to saltmarsh areas above regular high tide. Clarke and Hannon (1967) analysed the geomorphic factors affecting development of halophytic vegetation in other estuaries in the Sydney region. They concluded that the small size and rugged sandstone geology of these catchments produced little run-off and low sediment yields, thus limiting areas for the development of saltmarsh. This has also been applied to the Parramatta River (Lynch et al. 1976, EDAW and Environmental Partnership 1997), despite a quite different geology on the southern shores and in the upper reaches, with the conclusion that saltmarsh existed there also only as a narrow band behind the mangrove zone (DEP 1986c). Clarke and Benson (1988), using historical evidence, note that saltmarsh was extensive at Homebush Bay but few other studies discuss the former extent of saltmarsh. General terms, such as 'extensive wetlands' or 'extensive mangroves and saltmarsh' are more common descriptions (Karskens 1986, Benson and Howell 1990, Connell Wagner 1995, Register of the National Estate n.d., a–g).

There is also limited consideration of the extent of inter-tidal mudflats. A 1975 study notes (unsourced), that the heads of bays such as Iron Cove, Hen and Chicken, Yaralla, Majors and Homebush 'originally had extensive mudflats' (University of Sydney 1975) but above Homebush Bay the areas filled behind the seawalls were 'previously (intertidal) mangrove swamps'. The most consistent recognition of the presence and extent of mudflats is for Homebush Bay where they were 'extensive' and bordered by mangroves and saltmarsh (Benson & Howell 1990, Webster & Kachka 1992, Olympic Coordination Authority 1997).

These perceptions of former wetland distribution have been reinforced by ecological inference from current distribution, as in the description of the river at Parramatta at the time of first settlement: 'there would have been mangroves, *Avicennia marina,* below Church Street' (Benson & Howell 1990). They are also reinforced by concepts of wetland spatial zonation and temporal succession first described for the Sydney district by Hamilton (1919) and Collins (1921) and later detailed in a model of primary succession in wetlands of the NSW central coast by Pidgeon (1940). This model describes successive zones from the water's edge of mangroves, which colonise mudflats as soon as they reach above low-tide level, saltmarsh, rushes and sedges, and finally casuarinas and melaleucas. Clarke and Hannon (1967, 1969, 1970, 1971) described similar zonation in several study sites to the north and south of Sydney. Thus the 'natural' or historical pattern of wetland vegetation along the Parramatta River foreshores from the water is consistently taken to be the successive zones of Pigeon's (1940) model (Karsens 1986, DEP 1986c, Benson & Howell 1990, NSW Property Services Group 1992, Kachka 1993, EDAW and Environmental Partnership 1997).

Whilst this pattern can be found in many places along the NSW coast (Adam et al. 1988), it is not universal. Clarke and Hannon (1967) found distinct patterns of zonation in some localities around Sydney but no discernible pattern in others. Kratochvil et al. (1973) mapped wetland communities at Smiths Creek, a tributary of Broken Bay, which displayed great variation in species associations and community patterning with all three major community types, mangroves, saltmarsh and casuarinas along the water's edge. Extensive saltmarshes not associated with mangroves have been found fringing the southern part of Wallis Lake, near Forster on the NSW north coast (Adam et al. 1988). Maps of the distribution of mangroves and saltmarsh on the Parramatta River for 1945–53 (Moss 1987) show saltmarsh along the water's edge without a mangrove fringe in a number of locations from Homebush Bay upstream, as do Clarke and Benson's (1988) map of Homebush Bay for 1931. In examining the temporal aspects of Pidgeon's model using several lines of evidence, Mitchell and Adam (1989a) could not find evidence to support Pidgeon's model of saltmarsh succeeding mangroves in the Georges River and Botany Bay system.

There are limited studies for the period prior to the 1930s. Hamilton's (1919) study of mangroves and saltmarshes of the Sydney District, included specific examples from the Parramatta River such as in Iron Cove, Hen and Chicken Bay, Homebush Bay and Duck River, but there is little indication of the distribution and areal extent of these communities in these locations. Benson and Howell (1990) refer to limited primary source material in describing the foreshore wetlands of the Parramatta River as part of a wider study of Sydney's former vegetation. Clarke and Benson (1988), in discussing 200 years of change at Homebush Bay, used descriptions of 1843 and 1919 and mapped 40 years of change from the aerial photos 1930–1970. However, they did not consider the impact of dredging activity from 1905–1917 (McLoughlin in press) in shaping Wentworth Bay and the intertidal zone of Wentworth Point.

Materials and methods

A broad array of materials and sources was searched for evidence on the nature of the foreshores and foreshore vegetation of the Parramatta River before 1940: written material (Table 1), pictorial material in paintings and drawings and photographs (Table 2), and cartographic evidence in maps, charts and plans (Table 3).

Items discussed below are referenced to the tables thus: (table no: item no).

The cartographic evidence of the late 19th century was determined to be particularly useful and the data from a series of plans was used to compile a single map of the distribution and extent of mudflats, mangroves and saltmarsh in the 1880s–90s.

Evidence formats — discussion

Written material describing the European settlement of Sydney, its environment and the native people over its first ten years from 1788 is relatively abundant. After this, material on the immediate environment of Sydney is limited until the 1820s when travellers began to arrive and record their experiences for publication in Europe. However, soils and farming land were of more immediate interest to the settlers and description of wetlands and foreshore vegetation is less frequently found.

Of the pictorial material available, Sydney's early landscape paintings and drawings provide a far more accurate portrayal of the nature of the landscape and its vegetation than traditional critical comment has acknowledged (McLoughlin 1999). They can thus be a valuable source of evidence, either in the absence of any other evidence, or to assist in substantiating material from other sources. However, production primarily as artworks for exhibition or commercial publication, rather than simple landscape records, may affect their credibility, particularly if they are the only source of evidence or if they conflict with other sources. From the 1870s black and white photographs also become available.

Several key locations or views were favoured by painters and photographers and these appear repeatedly through the period, providing some indications of change. At Parramatta one such location was in the vicinity of the wharf looking downstream around the bend in the river, often as far as the Female Orphan School perched high above the river. As a major feature in a commanding position, the Orphan School was frequently painted in its surrounding landscape and it was also used as a point from which take views. Further downstream, homes and other buildings (signs of development and progress) on the northern bank were also favoured subjects. These included 'Vineyard', later 'Subiaco' (between Vineyard and Subiaco Creeks), the home and brewery of James Squires (Putney), 'Cleves' (Putney), and the Asylum (Gladesville).

Table 1. Description of the Foreshore Vegetation of the Parramatta River, 1788–1933.

	Observation	Location	Year	Observer and Source
1	*...about 4 mile higher than where the ships lay, the country was open and improved the farther we went up & in most places not any underwood, grass very long.*	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 75
2	*...along the bank the grass was tolerably rich and succulent, and in height nearly up to the middle, interspersed with a plant much resembling the indigo.*	Above Duck River	1788	Surgeon John White, White 1962, p. 127
3	*The banks of it were now pleasant, the trees immensely large, and at a considerable distance from each other; and the land around us flat and rather low, but well covered in the kind of grass just mentioned.*	Above Clay Cliff Creek	1788	Surgeon John White, White 1962, p. 128
4	*About two miles below this settlement, the harbour becomes quite narrow, being not more than ten or twelve yards across, and the banks are about six feet high: here the country has the appearance of a park. In rowing up this branch, we saw a flock of about thirty kangaroos or paderong, but they were only visible during their leaps, as the long grass hid them from our view...*	3–4 km down-stream from Parramatta	1790	Lt. Phillip Gidley King, King 1968, p. 402
5	*Went into the SW branch, found it terminate in snug Coves, surrounded with Mangroves, rather shoal water.*	harbour	1788	Lt. William Bradley, Bradley 1969, p. 76
6	*Those coves above where the ships lay were surrounded by Mangroves & had Mud flats at the bottom...*	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 79
7	*For it is strikingly singular that three such noble harbours as Botany Bay, Port Jackson and Broken Bay, alike end in shallows and swamps filled with mangroves.*	harbour	1792	Lt. Watkin Tench, Tench 1961, p. 64
8	Description of romantic scenery along the river which included *mangrove avenues and picturesque rocks*	Parramatta River	1793	Thomas Watling, artist Watling 1979, p. 23–24
9	On a shooting expedition to 'the Flats': *We landed on some low land or swamp, every step we took was up to our ankles in water...we walked in this manner for some hours seeing amazing quantities of ducks &c...after walking some hours we came to a brush which with the greatest difficulty we got through...but also up to our ankles in mud every step...*	Homebush Bay	1793	Richard Atkins, Judge-Advocate, Atkins 1791–1810, p. 120–21
10	*I had hardly touched ground when I found two tetragonias and various other oraches, all edible ...Then I saw a lythrum, the three geraniums already mentioned, three new species of lobelia, the mangrove, three banksias, the casuarina and many other plants.*	S shore about $^{1}/_{2}$ way to Parramatta	1793	Luis Nee, naturalist, Cavanilles 1990, p. 155
12	Discussion of usefulness for boat timbers of *mangrove which grows in the upper end of the Coves and swamps.*	harbour	1794	Daniel Paine, Paine 1983, p. 38
14	Reports on supply of fine timber and charcoal from a Government farm at Long Bottom (now Canada Bay), *as well as Mangroves used for the Stone masons and cutters mallets.*	Hen and Chicken Bay	1819	Major George Druitt, Ritchie 1971, p. 6
15	Report on possible crossings of the Parramatta River mentioning *the different Mangrove Swamps on the West Side of Hen and Chicken Bay.*	H. & C. Bay	1828	Major Thomas Mitchell, Mitchell 1828
16	Description of the Great North Road passing Hen and Chicken Bay: *Its shores are low with mangrove flats.*	H. & C. Bay	1832	James Raymond, Raymond 1966, p. 75

Observation	Location	Year	Observer and Source
17 *One portion of our land at Homebush consisted of salt-water marshes, covered in high tides and producing immense quantities of samphire. ...the mangrove grew very luxuriantly on the brink of the salt-water all along the* embankments (of drains cut through the marshes)*...these belts of green skirting the water were of great value in our view, and the sailing boats which passed daily up the creek glancing behind and between the groups of mangroves...*	Homebush Bay, between Powells & Haslems Cks	1843	Louisa Meredith, Meredith 1973, p. 155
18 *...beautiful bays branch off to each side: the water-worn sandstone rock is covered with gnarled gum and grass trees* (lower reaches)*... further up, the river, becoming more narrow, winds a good deal, and here and there are to be seen neat cottages, or elegant villas, the gardens and orangeries sometimes extending to the waterside.*	Parramatta River	1850	John Henderson, Henderson 1851, p. 103
19 *There are two species belonging to the Corolliflorae which abound on the banks of the Parramatta River (Aegeciras fragrans and Avicennia tomentosa). ...Near these may be seen Myrsine variabilis.*	Parramatta River	1859	William Woolls, Woolls 1867 p. 6
20 Iron Cove Creek runs *south-west out of Long Cove, with mud flats and mangroves along one shore, and around the next point* (Rodd Point), *Iron Cove, a little semi-circular bay, also lined with mangroves at its head.*	Iron Cove	1898	McLaurin & Hunt, McLaurin & Hunt, p. 60
21 Two branches of Powells Creek cross the 'marsh' near Concord West railway station: *banks of the shallow waterways are lined with Mangroves which display a graduated reduction in development as the channels merge into the plain.*	Homebush Bay	1919	A.A. Hamilton, Hamilton 1919
22 *...the heads of the bays are more or less like Iron Cove, all mangrove swamps, and there are possibilities of reclamation and of conversion into useful areas, Canada Bay, Exile Bay, Majors Bay, Yaralla Bay.*	Lower river, southern bays	1933	Chairman, Reclamation Trust of NSW, Maritime Services Co-ordination Board 1933

Table 2. Paintings, drawings and photographs of the Parramatta River.

No	Year	Creator	Title	Format	Location	Picture Location
1	1788	William Bradley	*A View in upper part of Port Jackson; when the fish was shot.*	watercolour	Difficult to locate	William Bradley (1960) opp p. 120
2	1798	unknown	*Captain Waterhouse's house, Sidney, Vineyard, about 1798*	watercolour	East side Vineyard Creek	ML SSV1B/PARR/6
3	1807	Attributed to G.W. Evans	Parramatta	watercolour	From Parramatta wharf looking downstream	ML SV1B/PARR/9, McCormick (1987) Pl. 132
4	1809	Unknown	*The landing place at Parramatta Port Jackson*	watercolour	From Parramatta wharf looking downstream	ML PXD388 Vol. 3 f.5, McCormick (1987) Pl. 133
5	1824 –25	Joseph Lycett	*Kissing Point, NSW*	aquatint	From Uhrs Pt. downstream across Rocky Point on S, Kissing Pt. on N	Lycett (1825)

No	**Year**	**Creator**	**Title**	**Format**	**Location**	**Picture Location**
6	1824 -25	Joseph Lycett	*View of the Female Orphan School*	aquatint	From south bank slightly upstream (position of James Ruse Drive)	Lycett (1825)
7	1824 –25	Joseph Lycett	*View of a Residence near Parramatta the property of John McArthur Esq.*	aquatint	From the Orphan School looking SW across river to Elizabeth Farm	Lycett (1825)
8	1825	Augustus Earle	*The Female Orphan School, P'matta, NSW*	watercolour	Looking downstream past Orphan School on high bank.	NLA Image 08144, Collison (1986) p. 8
9	1825	Augustus Earle	*A View in Parramatta, NSW*	watercolour	Looking downstream from near wharf.	Views N.S. Wales ML ZPX D265
10	1835	T. Godfrey	*The Orphan School, Parramatta NSW*	drawing	From directly across river	ML, Collison (1986) p. 1
11	1835	Robert Russell	*Parramatta, 5th Dec 1835*	watercolour	Looking downstream from near wharf	NLA Image 8789
12	c. 1837	Conrad Martens	*Parramatta River*	painting	View upstream to Parramatta from Orphan School	Art Gallery of NSW
13	1838	Conrad Martens	*Parramatta*	painting	View upstream to Parramatta from Orphan School	Parramatta City Council (1950) p. 9
14	1838	Conrad Martens	*(View of Parramatta)*	watercolour	View upstream to Parramatta from Orphan School	ML ZDLPg 15, Ellis (1994) p. 152
15	1840	Unknown	*Orphan School Reach*	sepia ink drawing	Looking directly upstream past Orphan School from downstream on water	de Falbe (1988) p. 19
16	1840	Unknown	*Red Bank and Farm*	pencil drawing	From N bank across to mouth of Clay Cliff Creek	de Falbe (1988) p. 19
17	1840	Attributed to F. Montague	*Female Orphan School, Parramatta*	painting	Looking across river and downstream from S bank	Collison (1986) p. 11
18	1840	Henry C. Allport	*Cleves*	ink & watercolour	Northern shores at Putney from S shore, east side of Uhrs Point.	*Sketches in Sydney* ML ZPXD 86 f.17
19	1840	Henry C. Allport	*Cleves - Parramatta River*	ink	Northern shores at Putney from S shore, east side of Uhrs Point	*Sketches in Sydney ...* ML ZPXD 86 f.31
20	1847	Unknown	*Parramatta NSW*	watercolour	Looking down stream from near wharf	ML ZDL PXX39 f.14

No	Year	Creator	Title	Format	Location	Picture Location
21	1850s	Unknown	*Byrnes Bros' flour mill and the George St. Barracks in the 1850s*	?	Looking down stream from near windmill	Parramatta City Council (1950) p. 13.
22	1858	Henry G. Lloyd	*Parramatta, NSW*	watercolour	Looking up-stream from S bank near present Alfred Street	*Sketches of N.S. Wales*
23	1860	C.F. Terry	*Tarban Point*	lithograph	Looking up Parramatta River at mouth of Tarban Creek	NLA Image. 9146, Terry 1860
24	1860	C.F. Terry	*Lunatic Asylum*	lithograph	From south side on Great North Road, Concord, across to Gladesville	NLA Image 9145, Terry 1860
25	1860	C.F. Terry	*From Kissing Point*	lithograph	From Top Ryde across River to Uhrs Point, Brays Bay, Homebush Bay	NLA Image 9147, Terry 1860
26	1860	C.F. Terry	*Subiaco c. 1860*	lithograph	From S bank across River to Rydalmere.	NLA 9148, Terry 1860
27	1860	C.F. Terry	*Parramatta*	lithograph	Parramatta River, Parramatta	NLA 9149, Terry 1860
28	1867	G.P. Slade	*Parramatta River*	watercolour	-	NLA Image 7643
29	1870	GPO	*Subiaco, Parramatta River, near Parramatta*	B&W photo	From directly across river on Grand Ave.	ML GPO1: 06145
30	1870	GPO	*Byrnes' Mill on Parramatta River n the 1870s*	B&W photo	From the Orphan School fence looking upstream to Parramatta	ML GPO1: 06146
31	1870s ?	GPO	*Protestant Orphan School, Parramatta*	B&W photo	From across river downstream	ML GPO1: 06139
32	1870s	GPO	*View of Protestant Orphan School*	B&W photo	From directly across the river	ML GPO1: 06131,
33	1880	Gibbs Shallard & Co.	*Parramatta River near Ryde*	B&W photo	From Top Ryde across river to Uhrs Point Brays Bay Homebush Bay	Gibbs, Shallard & Co. (1880)
34	1880s	W. Clarsen	*Iron Cove*	lithograph	Looking across Rodd Island	NLA Image 20600
35	1881	?	*Iron Cove, 1881*	B&W photo	?	ML Small Picture File
36	1890	John Paine	*Iron Cove*	B&W photo	From Birkenhead Pt across bridge to Callan Park	MM 82\039\697
37	1892	Dept. of Public Works	*View at Long Cove, suction dredge at work reclaiming land*	B&W photo	Iron Cove	Public Works Dept. 1892 p. 139

No	Year	Creator	Title	Format	Location	Picture Location
38	1892	Dept. of Public Works	*View at Long Cove showing canal, floating and shore discharge pipes*	B&W photo	Iron Cove Hawthorne Canal	Public Works Dept. 1892 p. 141
39	1914	GPO	*Parramatta River view*	B&W photo	Possibly from Meadowbank Park (Ryde Bridge) upstream across Wentworth Pt.	ML GPO1: 17488
40	1914	GPO	*Parramatta River views: from Abbotsford*	B&W photo	Possibly at Quarantine Reserve on Hen & Chicken Bay	ML GPO1: 17483
41	1914	GPO	*Parramatta River view*	B&W photo	Possibly in a bay on the northern shores	ML GPO1: 17482
42	1927	Concord Council	*The swampy nature of the ground around Exile Bay before reclamation*	B&W photo	Part of Hen & Chicken Bay, Parramatta River	Coupe (1983) p. 170.
43	1928	Melvin C. Kent	*Homebush Bay*	B&W oblique aerial photo	Across Ryde Bridge, full view of Homebush Bay	ML GPO1: 24964
44	1928	Melvin C. Kent	*Parramatta River west of Ryde Railway Bridge*	B&W oblique aerial photo	From above river near Putney, across Ryde Bridge & Homebush Bay	ML GPO1: 24971
45	1928	SHT	*Parramatta River at Camellia, looking east*	B&W oblique aerial photo	-	ML GPO1: 24975
46	1930s	-	*Looking west over Parramatta*	B&W oblique aerial photo	From down-stream of wharf	MM 83\066\0359b
47	1932	Sydney Mail	*A Swamp calling for Reclamation*	`B&W photo	Across the head of Canada Bay from the southwest	Official Consultative Committee (1932) p. 33
48	1930s	-	*Looking east over Concord Golf Course*	B&W oblique aerial photo	Across golf course and head of Majors Bay now Majors Bay Reserve	MM 83\066\0504
49	1936	MWS&DB	*18" Submain crossing Major's Bay to P.S. No. 90 Concord.*	B&W photo	From west shore south of the main, east across head of Bay	Sydney Water Archives
50	1936	MWS&DB	*18" Submain crossing Major's Bay to P.S. No. 90 Concord.*	B&W photo	From grounds of 'Yaralla' north of the main looking south-east	Sydney Water Archives

Notes to Table 2.

GPO = Government Printing Office, ML = Mitchell Library, State Library of New South Wales, MM = Macleay Museum, University of Sydney, NLA = National Library of Australia, MWS&DB = Metropolitan Water Sewerage & Drainage Board, SHT = Sydney Harbour Trust

Mitchell Library GPO images and National Library images can be viewed online via the respective library websites.

Table 3. Maps, Charts and Plans of the Parramatta River.

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
1	1789	*Chart of the Coast between Botany Bay and Broken Bay*	John Hunter	Includes Hawkesbury Parramatta & Georges Rivers	Hunter (1968), opp. 160
2	1789	*Port Jackson, Chart 6*	William Bradley	Port Jackson, Middle Harbour, Lane Cove River, Parramatta River	Bradley (1969)
3	1789	*The Channel to Rose Hill, Chart 11*	William Bradley	Parramatta River, Homebush Bay, Duck R., Haslems Ck., Powells Ck.	Bradley (1969)
4	1828, Dec.	*Sketch of Part of the Parramatta River Showing the proposed Situations for a Punt near Kissing Point.*	T. Mitchell H.F. White, Darcy	Parramatta River, Hen & Chicken Bay, Brays Bay, Majors Bay	SR Map 3221 SR Map 3222 SR Map 3223
5	1833, June	*Sketch of the Parramatta River near Redbank*	Thomas Mitchell	Parramatta River, Rydalmere	CP NLD P.843a, SR Map 4903
6	1833, Dec.	*Survey of part of the Parramatta River*	Mathew Felton	Parramatta River, Rydalmere, Camellia	CP NLD P.843, SR Map 4902
7	1840	*Map of Port Jackson and the Parramatta River NSW*	Brownrigg & Meadows	Parramatta River, Homebush Bay, Duck River, Parramatta	ML ZM3811.15/ 1840/1
8	1842	*Plan of a Site for a Village at Longbottom*	Galloway	Hen & Chicken Bay, Parramatta R.	SR Map 3381
9	1845	*Proposed Road in Parish of Hunters Hill*	J.J. Galloway	Parramatta River	ML ZM3811. 1423/1845/1
10	1856	*Sketch shewing the unoccupied Land at Longbottom*	- -	Hen & Chicken Bay, Homebush Bay, Parramatta River, Longbottom	LA V & P 1863-64 (5), p. 668
11	1857	*Plan of 22 Villa Sites on the Three Brothers Point opposite Five Dock, Parramatta River.*	E.J.H. Knapp	Parramatta River, Henly	ML ZMZ811. 1421/1857/1
12	1867	*Survey of Mr B.C. Rodd's Water Frontage, Iron Cove*	W. Orr	Iron Cove, Rodd Point, Fivedock	CP C935-690
13	1867, Sept.	*Survey of Mr B.C. Rodd's Water Frontage to Hen & Chicken Bay in connection with his application to be allowed to reclaim.*	W. Orr	Hen & Chicken Bay, Parramatta River	CP C965-690
14	1881	*Permanent Harbour Survey Long Cove etc*	J. Deering	Iron Cove, Parramatta River	CP 105-574
15	?	*Tracing showing part of the Water Frontage of Hen & Chicken Bay at Longbottom, Parish of Concord, County of Cumberland*	-	Hen & Chicken Bay, Canada Bay	CP 141-574
16	1883?	*Plan showing the foreshores at Fivedock Bay, Parramatta River, Parish of Concord, County of Cumberland*	-	Parramatta River, Five Dock Bay, Chiswick	CP 196-574

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
17	1883, Aug.	*Tracing shewing High Water Mark Chiswick Estate, Fivedock Bay, Parramatta River, Parish of Concord, County of Cumberland*	John Deering	Parramatta River, Five Dock Bay Chiswick	CP 197-574
18	1884, Nov.	*Plan showing Portions of River Frontage and Mortlake Road, Parish of Concord, County of Cumberland*	William L. King	Parramatta River, Mortlake, Majors Bay	CP 174-574 (C39-440)
19	1888, Aug.	*Part of Hen & Chickens Bay, Parish of Concord, County of Cumberland, shewing Positions of High and Low Water Marks and Frontage Detail*	Walter Mills	Hen & Chicken Bay, Canada Bay	CP 71-440
20	1888 Oct.	*Plan shewing survey of Mean High, and Low Water Marks on the western side of Hen & Chicken Bay, Parish of Concord, County of Cumberland*	George Knibbs	Hen & Chicken Bay, Exile Bay, France Bay, Cabarita	CP 72-440
21	1891	*Parramatta River from Homebush Bay to Queens Wharf, Parramatta — Compiled*	-	Homebush Bay, Parramatta River	CP 567-3000
22	1892	*Port Jackson Harbour Frontage from Bedlam Wharf to Gladesville Wharf*	Francis J. Gregson	Parramatta River, Looking Glass Bay	CP 209-574
23	1892, May	*Plan showing an area proposed to be dedicated as a reserve in connection with the Yaralla Hospital, Parish of Concord, County of Cumberland*	Walter Mills	Brays Bay	CP 656-3000
24	1892	*Port Jackson Harbour Frontage Gladesville to Parramatta*	V. Stephen	Parramatta River, Glades & Morrisons Bays	CP 207-574
25	1893	*Mean High Water Mark Parramatta and Duck Rivers*	V. Stephen	Parramatta River, Duck River, Homebush Bay	CP 230-574
26	1893	*Plan of Homebush Bay*	-	Homebush Bay, Parramatta River	CP 2977-3000
27	1926, June	*Proposed Reclamation Iron Creek Bay, Long Cove*	-	Iron Creek, Iron Cove	SHT file 32/6782 (SR 13/13878)
28	1919	*Soundings, Newington Wharf to Parramatta Tramway Wharf*	-	Parramatta River from Duck River downstream	SHT file 32/2796 (SR 13/13860)
29	1925	*Newington Wharf to Silverwater Wharf, Parramatta River*	G. Hart	Parramatta River from Duck River downstream	SHT file 32/2796 (SR 13/13860)
30	1930	*Hydrographic Survey, Broadoaks Estate, Parramatta River*	G. Hart	30 & 31 together cover approx. 1 km downstream from Duck River	348^{S} & 375^{S} in SHT file 31/6911 (SR 13/13864)

Table 3. cont.

No	Date	Title	Creator	Location/ Coverage	Source/Plan No.
31	1931	*Hydrographic Survey, Parramatta River*	G. Hart	30 & 31 together cover approx. 1 km downstream from Duck River	348^{S} & 375^{S} in SHT file 31/6911 (SR 13/13864)
32	1938	*Plan showing Hydrographic Survey between Charles St. Parramatta and Duck River, Parramatta River*	MSB	Parramatta River	Sydney Ports Authority, Roll 25 Sh 1
33	1939	*Duck River, Granville*	Dorman	Duck River, Parramatta River, Redbank	CP 12044-3000

Notes: SR = State Records of New South Wales, CP = Crown Plan, ML = Mitchell Library, State Library of New South Wales, LA V & P = Legislative Assembly (of NSW) *Votes and Proceedings*, SHT = Sydney Harbour Trust, MSB = Maritime Services Board of NSW.

Original Crown Plans are held by the Department of Land and Water Conservation (unless shown as SR Map), microfilm copies by the Registrar-General's Office.

Early pictures of the lower portions of the river and its bays are limited. Artists focussed on the main settlements and their settings — Sydney Cove and the surrounding harbour, and Parramatta. Up to the 1870s images are predominantly of the upper river, after the 1880s they are predominantly of the lower river.

Presence or absence of mangroves, specifically the Grey Mangrove, *Avicennia marina* (L.) Blanco, which forms pure stands, is the most easily identified feature of foreshore wetland vegetation in pictures. Not only is their location on the edge of the water a key indicator, but mangroves have a distinct dense rounded canopy which generally reaches ground/water level on the outer edges of a line or cluster of the trees. Eucalypts and casuarinas (specifically Swamp Oak, *Casuarina glauca*) also have distinctive forms, but different from mangroves. Low green areas are more problematic and may be saltmarsh or cleared grassed areas above high tide. Mudflats may be shown, but their absence may simply mean the picture depicts high tide.

Maps and plans can provide detailed and accurate information on the former distribution and extent of wetlands, especially larger scale survey plans. Maps of the Parramatta River commence with the charts drawn up by officers of the First Fleet, notably John Hunter and William Bradley. After Bradley, little of the inter-tidal zone of the Parramatta River was mapped until 1828 when a portion of the river between Brays Bay and Abbotsford was surveyed to fix a suitable crossing point (3:4). Prior to the 1860s, minimal vegetation, soils and topographic information was marked on surveys or on portion plans (surveys of individual parcels of land to be alienated from the Crown by grant or sale) but in 1864 Crown surveyors were directed to include this information (Jeans 1978). Surveys taken later in the 19th century can thus provide a detailed snapshot of a period 40–50 years prior to aerial photographs.

The most significant cartographic evidence of the former extent of mudflats, mangroves and saltmarsh in the Parramatta River derive from a series of surveys of the 1880s and 1890s (3:14–26). As dredging and the demand for reclamation of mudflats gathered pace (McLoughlin in press), there was a need to survey the harbour foreshores to establish the line of high and low water marks and limit lines for reclamation. Plans 14, 22, 24 and 25 were part of this effort and were produced at large scale (one chain to the inch, 1: 792, or two chains to the inch, 1: 1584), on a series of large sheets. There is complete and detailed mapping of the northern foreshores from Bedlam Point (Gladesville) to Parramatta wharf and on the southern shores from Rhodes to Parramatta Wharf. On the south side downstream from Rhodes, with the exception of Iron Cove, surveys accessed for this paper are at similar scales but are less complete and evidence relies more on the inclusion of vegetation and other foreshore detail on waterfront property or other surveys (3:15–20).

Results

Lower River to Uhrs Point

From written descriptions it is evident that mangroves formed at least a part of the foreshore vegetation of the lower Parramatta River at the time of European settlement but it is not clear how extensive they were. Many references are general, or are not accompanied by precise location information. The earliest descriptions, from Bradley (1969), Tench (1961) and Paine (1983) (1:5, 6, 7, 12) indicate mangroves were clustered in coves at the heads of the bays on the southern shores. These bays were described as terminating or ending in 'snug coves' or shallows filled with mangroves. At that time bays were more indented than they are now, with a series of coves or minor embayments at tributary creeks (now walled and filled creating smoothly curved shoreline profiles). As the first surveys of the harbour were done from the water, the area of mangroves behind the shoreline fringe is not indicated. A description of the harbour 'ending' in 'shallows and swamps filled with mangroves (1:7) has been applied to upper river (Clarke & Benson 1988), but is more likely to describe the river at Homebush Bay. It is clear from a number of accounts (Bradley 1969, Phillip 1978, Paine 1983) that 'the Flats', the extensive intertidal mudflats and limited channels upstream from Uhrs Point (Fig. 2), were regarded as the head of the harbour.

The earliest painting of the lower river is by Bradley in 1788 (2:1), predominantly of rocky shoreline, but in the curves of two bays, or coves, bands of brighter green along the shoreline are likely to represent belts of mangroves. Although downstream from Uhrs Point, it is difficult to identify just where this picture is located, particularly given Bradley's tendency to exaggerate the vertical scale in rocks and cliffs, but it confirms his description of coves terminating in mangroves.

There are conflicting accounts of vegetation at the spot where two convicts cutting rushes (for roof thatching) were killed by Aborigines 'up the harbour', i.e. upstream from Sydney Cove, in 1788 (Hunter 1968, Tench 1961, Bradley 1969, White 1962, and Worgan 1978). A few miles by boat away from the settlement (Worgan 1978), in the 'southwest arm' (Bradley 1969), they were variously said to be found dead in the rushes or one or both in mangroves, but this incident indicates both mangroves and rushes (or reeds) were present, probably at the waters edge accessed by boat. An expedition by naturalist Luis Nee also indicates some variety in vegetation found on,

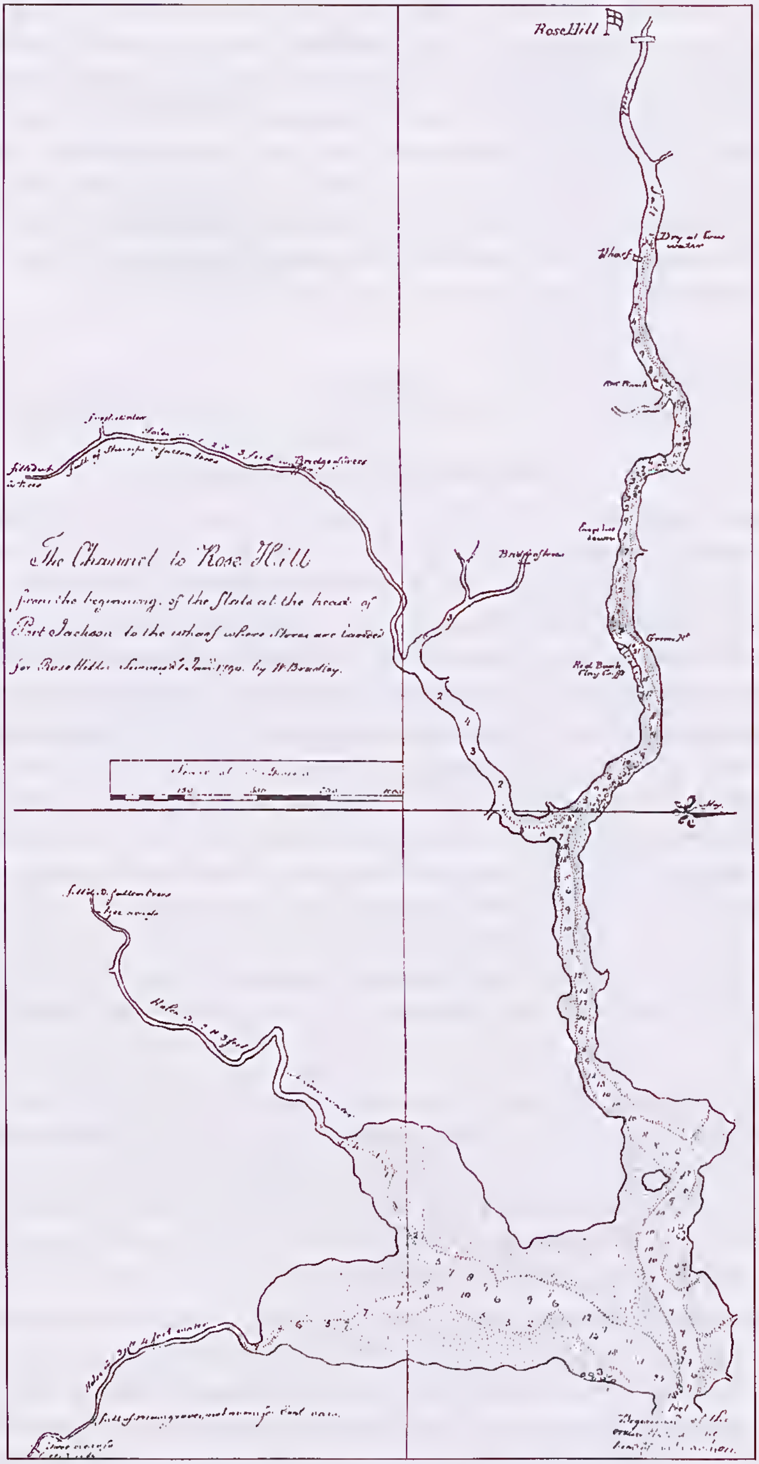

Rose Hill
Wharf
Dry at low water
Green Pt
Red Bank Clay Cliff
Bridge of trees
The Channel to Rose Hill
from the beginning of the flats at the head of Port Jackson to the wharf where Stores are landed for Rose Hill. Surveyed 1 Jan 1790. by W Bradley.
Fresh water
Bridge of trees
Beginning of the flats at the head of Port Jackson

Fig. 2. William Bradley, A Voyage to New South Wales 1786–1792, Chart 11 'The Channel to Rose Hill from the beginning of the flats at the head of Port Jackson to the wharf where the stores are landed for Rose Hill'. Homebush Bay, Duck River and Upper Parramatta River to Parramatta (Rosehill) wharf. (Mitchell Library, State Library of New South Wales)

or near, the water's edge, including the wetland species mangrove, casuarina and tetragonia (1:10).

In the 1820s and 1830s there is consistent evidence for the presence of patches of mangroves in Hen and Chicken Bay, both written (1:14–16) and in plans. Three versions of the 1828 survey of the river between Brays Bay and Abbotsford to fix a suitable crossing point (3:4) show patches of mangroves in Majors and Yaralla Bays and in two coves in the south and east parts of the head of Hen and Chicken Bay. The consistent orientation of the mangrove patches to the south and south-east of the bays and coves is striking, as are the presence of large inter-tidal zones not covered by mangroves. While the compiled map of the 1880s–90s surveys (Fig. 3a) is incomplete in its coverage of the shoreline, it confirms the patchiness of mangrove presence, their orientation to the southeast corners of the coves and the presence of large areas of inter-tidal mudflats in the southern bays of the lower river. By the 1930s, there were still large areas of saltmarsh and saltpan above normal high tide in Canada Bay (Longbottom) at the head of Hen and Chicken Bay (2:47) in the areas shown on Fig. 3a.

By 1927 a solid band of mangroves with an area of saltmarsh on the landward side was photographed in Exile Bay (part of Hen and Chicken Bay), prior to reclamation in the 1930s to create Edwards Park (2:42). In Majors Bay oblique angle aerial photographs of the 1920s show a large patch of mangroves is present covering most of the area to become Majors Bay Reserve (2:48). Ground photographs in 1936 (2:49–50) show most of these mangroves had been cut but were recolonising.

In Iron Cove an 1890 photo of Iron Cove Bridge from the north-east (2:36) includes the area of Callan Park which was to be reclaimed in 1893–94 (Public Works Department, 1893). Mangroves are not visible in this area in this photograph and the 1881 survey indicates the area was mudflats (Fig. 3a). Images of other parts of Iron Cove show the foreshores as cleared or open and grassy to the water's edge with scattered eucalypts and casuarinas (2:34, 35, 37). At the head of the bay change can be traced from 1881, when no mangroves are shown in Iron Creek (3:14, Fig. 3a). By 1898 mangroves are described as present on one bank (1:20) and by 1926 a large stand occupies half of the 1881 mudflats (3:27).

Further up river, Joseph Lycett's 1820s view of both banks from the vicinity of the present Ryde Bridge (2:5) gives no indication of mangroves, even around those points on the south side, now lined by this species. By the 1890s (Fig. 3a) the steeper rocky northern shores of the river had several generally very small patches of mangroves on mixed mud and sandy flats which were accumulating in bays and on parts of the shoreline. Hamilton (1919) notes saltmarsh fronted by a sandy shore at Meadowbank.

Brays Bay appears in 2:25 and 33, These broad views lack detail but it is still apparent that the part of Brays Bay within the view carries few if any mangroves, nor does the long foreshore of the Rhodes peninsula. Hamilton (1919) describes *Acacia falcata* lining the banks of Brays Bay and also notes the presence of a *Casuarina glauca* forest.

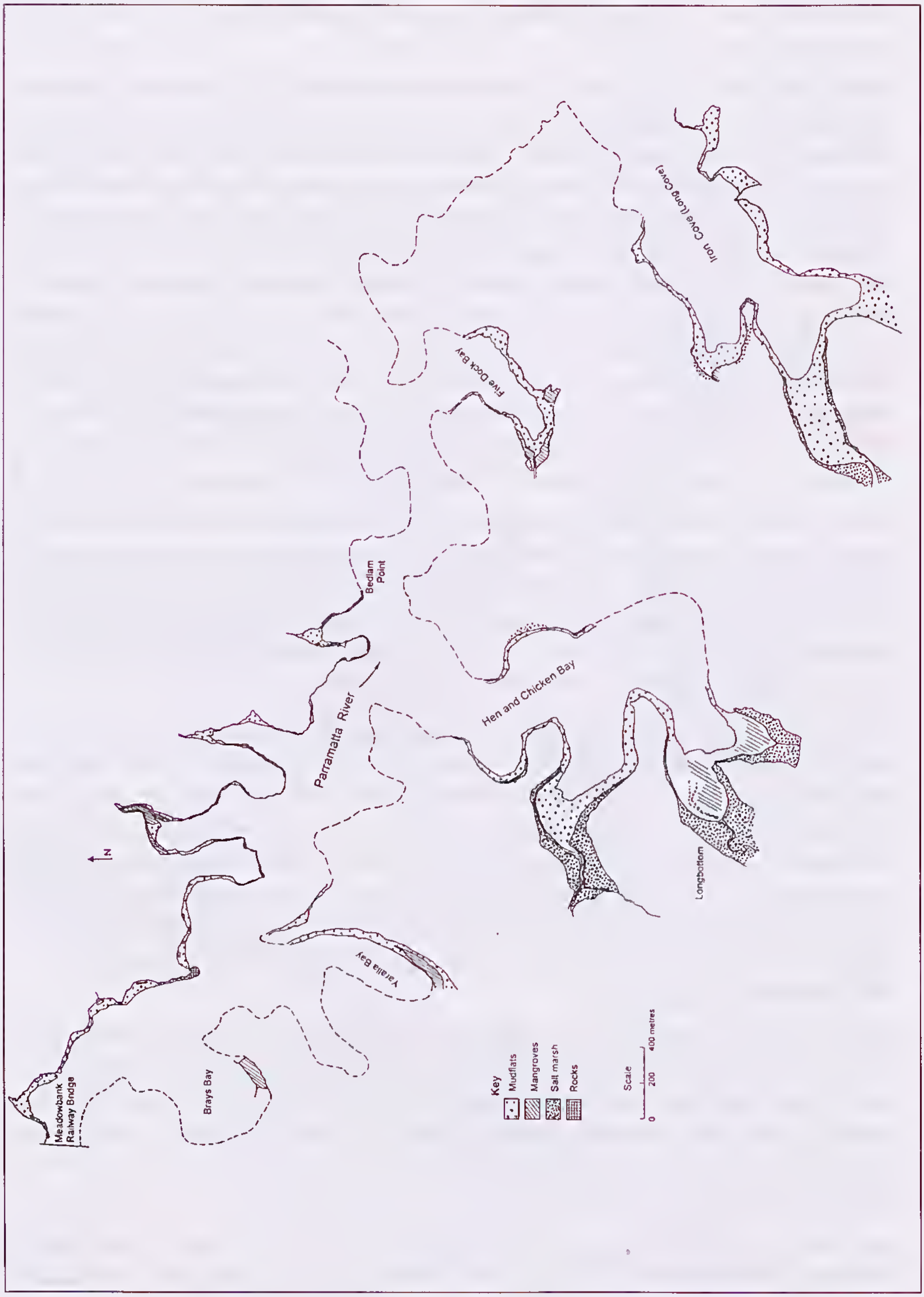


Fig. 3a. Composite map of wetlands of the Parramatta River in the 1880s and 1890s: Iron Cove to Meadowbank Railway Bridge, Charity Point. Compiled from Plans 14–20, 22–24 (Table 2). Some vegetation detail from Plan 12 also included. Dashed line indicates parts of shoreline for which no plan found showing wetlands in this period. Lack of a solid line boundary to wetlands reflects lack of a boundary on some plans where the inter-tidal zone was shown as context for the main purpose of the plan and their full extent was not surveyed.

Homebush Bay to Duck River

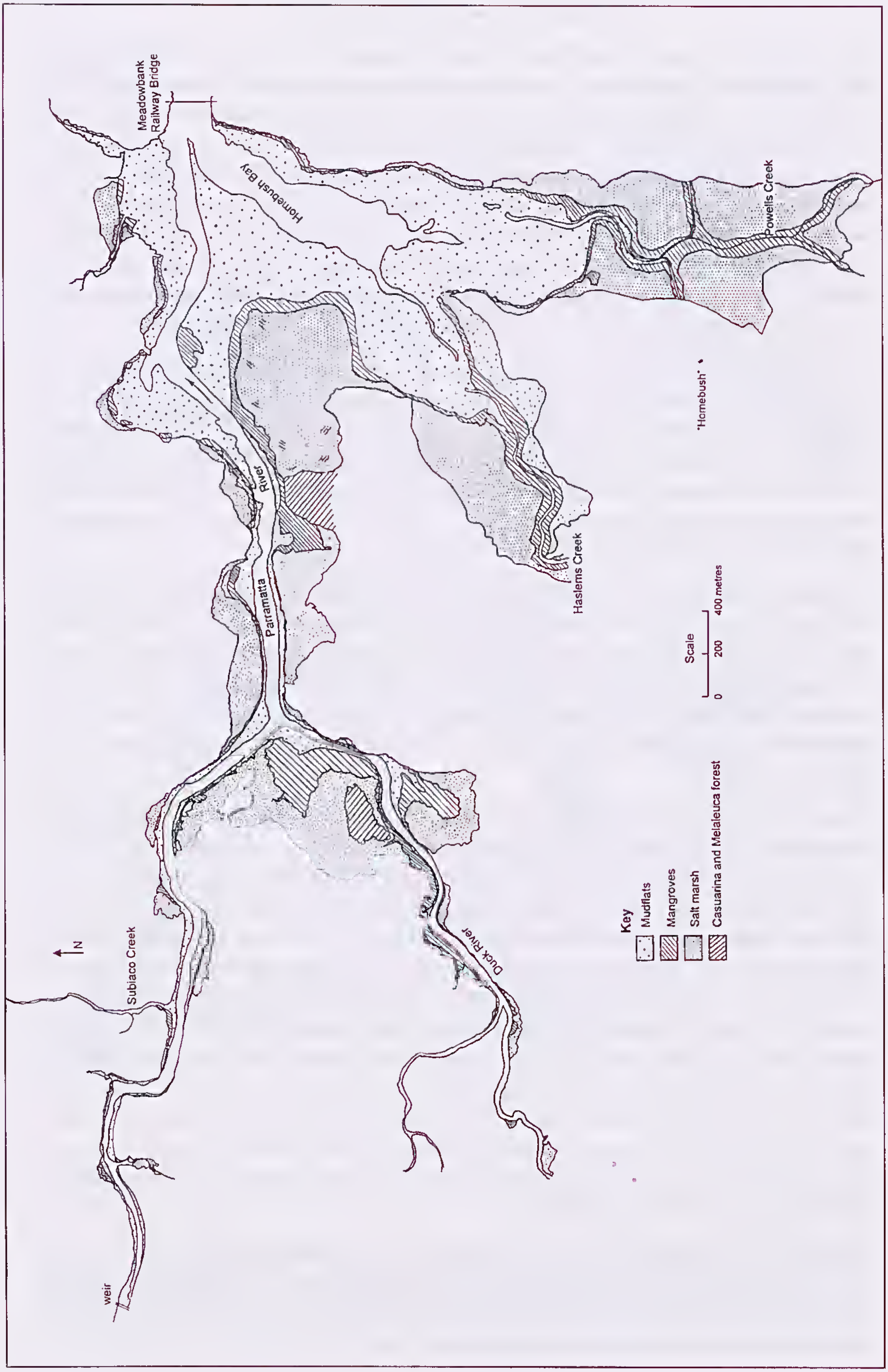
On Bradley's 1789 chart from Charity Point to Parramatta (3: 3, Fig. 2) both Homebush Bay and the river upstream are shown as predominantly consisting of inter-tidal areas cut by narrow navigable channels generally 2–3m deep. The 'Flats' could have been mudflats or saltmarsh but the stippled area on Bradleys chart did not carry mangroves — a mangrove island mentioned in his journal is delimited separately. 100 years later, a map compiled in 1891 (3:21) confirmed much of the topographic detail of Bradley's chart. Bradley's stippled areas were in fact extensive areas of mudflats and were still mudflats in 1891 (Fig. 3b) although the mudflats at the mouths of Haslams and Powells Creeks had prograded 190 m out into the Bay, presumably as a result of a century of clearing in the catchment and accelerated siltation.

In 1793 Atkins (1:9) appears to have spent hours tramping across saltmarsh at Homebush Bay before trying to get through a mangrove or casuarina/melaleuca thicket. Louisa Meredith (1:17) describes mangroves along the creeks and embankments of drains cut through the saltmarsh of Homebush Bay by the 1840s but on Powells Creek mangroves appear to have been discontinuous and there is no reference to large clusters of mangroves at Homebush Bay. Hamilton similarly describes mangroves lining channels at Homebush Bay in 1919 (1:21).

Confirming aspects of these earlier accounts, the plans of the 1890s (Fig. 3b) provide evidence of very extensive saltmarshes and mudflats from Homebush Bay to Duck River. Although there were several large patches of mangroves on Duck River and at Newington, mangroves were mainly restricted to fringes, generally narrow or in patches. There were also some large stands of *Casuarina* and *Melaleuca* forest. Both mangroves and casuarinas were found in small patches through the saltmarsh east of Newington.

Comparison of Fig. 3b with Clarke and Benson's (1988) maps from aerial photographs demonstrate the distribution of mangroves and saltmarsh on Haslams and Powells Creeks changed little between 1890 and 1930 except for the drainage channels east of the 'Homebush' residence, which no longer appear to be present in 1930. However there are dramatic changes in the wetlands of Wentworth Point on the westem side of the bay with most of the former mudflat colonised by both saltmarsh and mangroves. Construction of seawalls in the early 1890s along the western shore of the bay and around the point, followed by dredging and reclamation 1905–1917, substantially altered the topography and inter-tidal zone of the enclosed area. Pumping dredged sediment onto this area, or diverting sediment deposition, may have enabled the expansion of mangroves and saltmarsh apparent by 1930 by sufficiently raising the level of parts of this inter-tidal mudflat. From the 1940s the area of saltmarsh and mangroves progressively declined as the major reclamation project of 1948–61 shaped the present form of Homebush Bay.

Seawalls were extended further upstream to Duck River on the south side by 1913 (Sydney Harbour Trust 1931). Surveys in the kilometre stretch downstream of Duck River between 1919 and 1931 (3:28–31) show a few patches of expanding mangroves on the south side as prograding mudflats are colonised.


Meadowbank Railway Bridge
Homebush Bay
Powells Creek
River
Parramatta
'Homebush'
Haslems Creek
Scale
0
200
400 metres
Key
Mudflats
Mangroves
Salt marsh
Casuarina and Melaleuca forest
Duck River
N
Subiaco Creek
weir

There are few images of Homebush Bay, either paintings or photographs prior to the 1940s. In similar views across Rhodes peninsula and Homebush Bay from the high ridge above the river at Ryde in an 1860 painting (2:25) and an 1880 photograph (2:33) a dark band of mangroves is obvious along the shoreline of Homebush Bay, particularly in the 1880 photograph. Oblique angle aerial photographs of the river in the 1920s show extensive patches of mangroves in Homebush Bay and mangrove fringes along sections of the river banks upstream, although by no means continuous (2:43–46).

Upper Parramatta River above Duck River

In the narrow Upper Parramatta River, early descriptions give no hint of mangroves or other wetland vegetation, but rather of open banks and long grass (1:1–4). It would also not seem possible to see the houses and features mentioned by travellers as visible on a trip up the river in a small boat, if the river was lined with mangroves. These writers included Lt. King in 1790 (1:4), Peter Cunningham in the 1820s (1966) and John Henderson in the 1850s. The latter's description of the Parramatta River (1:18) contrasts markedly to his description of the Hunter estuary up river from Newcastle (150 km north of Sydney) where it begins to narrow and wind, 'the mangroves lining it to within the water's edge'.

Of 28 pictures (Table 2) created prior to 1870, 20 are of the river upstream from Subiaco Creek, Rydalmere. Only one shows vegetation that might be mangroves. Instead the banks are open to the waters edge with scattered or clumped eucalypts, casuarinas and other shrubs and small trees, or they are low cliffed banks about 2 m high (Fig. 4a) as King (1:4) described, in marked contrast to this stretch of river today (Fig. 4b).

The single painting (2:4) which possibly shows mangroves is so open to question that it cannot be taken as evidence without corroboration. Dated two years later than the very similar No. 3, small shrubs appear near the water on a bend on the northern bank downstream from Parramatta wharf. These shrubs are not present in No. 3 and could represent newly established mangrove seedlings. However, McCormick (1987) points out that other discrepancies between views 3 and 4 suggest that No. 4 was drawn from an 'earlier indistinct sketch'. In addition the shrubs are at some distance and not clearly depicted as in the intertidal zone, nor even on the water's edge. All other pictures of the same bend in the river have no mangroves present.

The pictures of and from, the Female Orphan School comprise the most consistent series anywhere on the river, depicting changes through to the 1870s. From the earliest views after its completion in 1818 the steep slope to the river in front of the school is open and grassed. But along the waters edge a narrow flat supports a continuous

Fig. 3b. Composite map of wetlands of the Parramatta River in the 1880s and 1890s: Homebush Bay to Parramatta wharf. Sources: Plan 21 (Table 2) — detail for much of Homebush Bay and for mudflats on most of map, Plan 25 — most of the saltmarsh and mangrove distribution, except west and south of Homebush Bay. Dated 1891 and 1893, the vegetation distribution on these two plans has a high level of agreement, except south of Haslams Creek where the zone beyond the mangroves is shown as 'salt swamp' on Plan 25, 'clay flat with mangroves in patches' on Plan 21. Density of shading for this area lies between mudflat and saltmarsh due to this discrepancy in the sources.

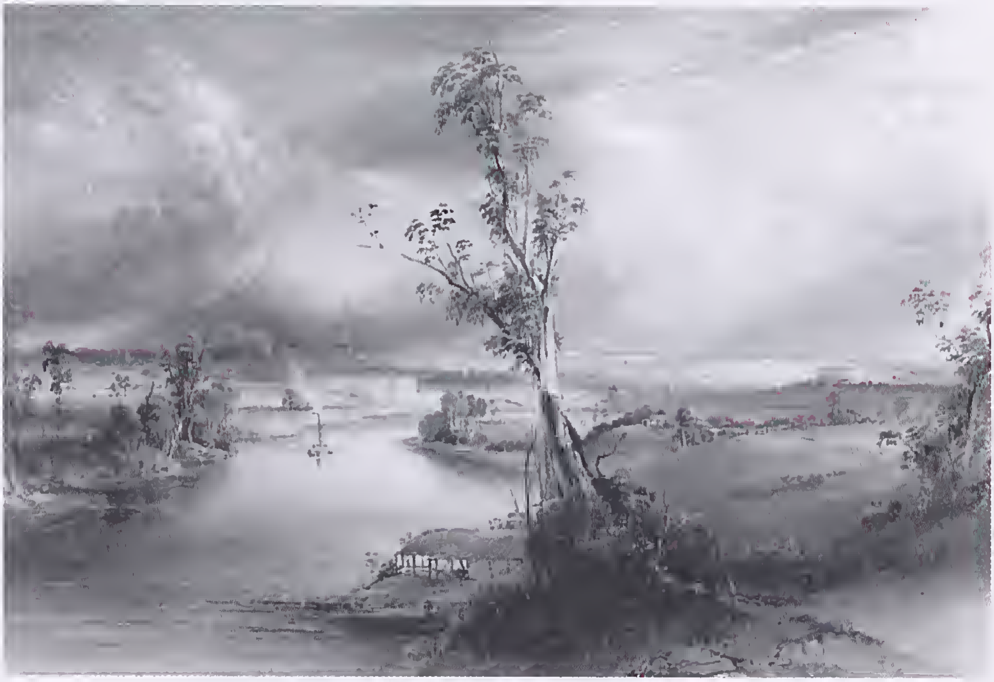


Fig. 4a. Parramatta c. 1837, Conrad Martens (The Clyde Bank Collection, Sydney). View upstream to Parramatta from Vineyard Creek. James Ruse Drive now crosses just beyond the boatshed on the water's edge. The entrance to Clay Cliff Creek, which winds up past Elizabeth Farm, is visible at left.

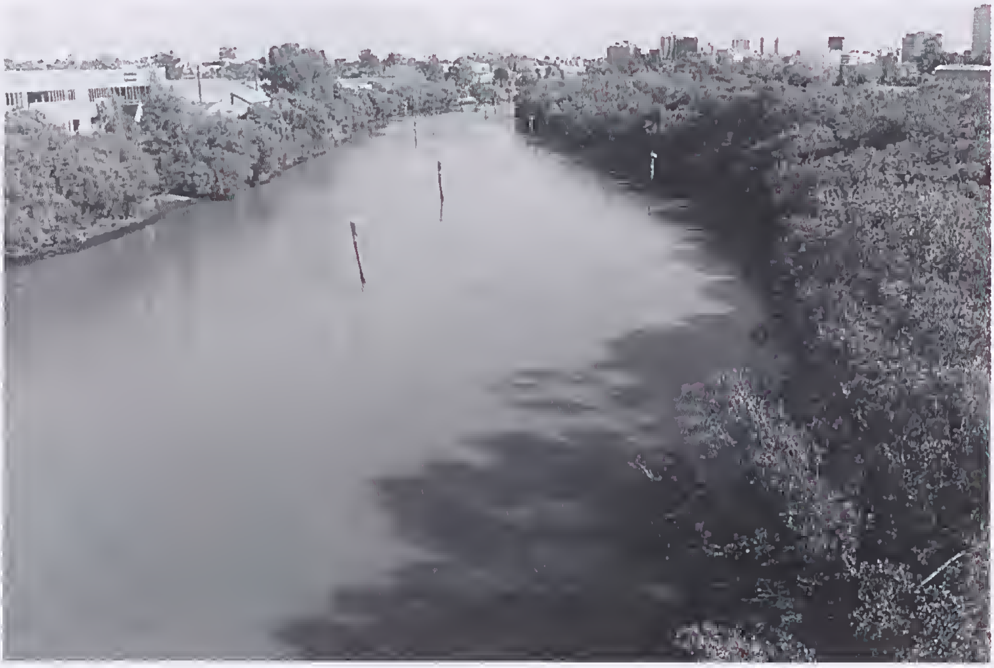


Fig. 4b. Parramatta River, 1999. View upstream from James Ruse Drive bridge over the river, of the same stretch of river as depicted in Fig. 4a. The entrance to Clay Cliff Creek is visible on the left.

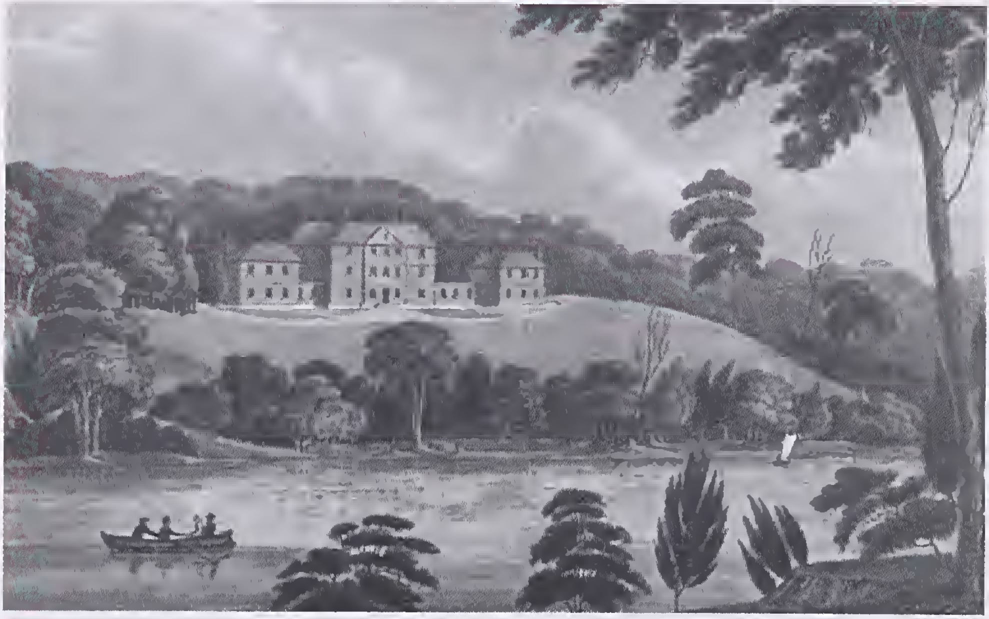


Fig. 5a. View of the Female Orphan School, Joseph Lycett, 1824 (Lycett 1824–5, Mitchell Library, State Library of New South Wales). Despite Lycett's stylised portrayal of landscape and vegetation, this image, along with others of both banks of this stretch of river listed in Table 2 (Nos 6–8, 10, 12–17) depicts a shoreline vegetation of a diversity of eucalypt, casuarina and shrub species.

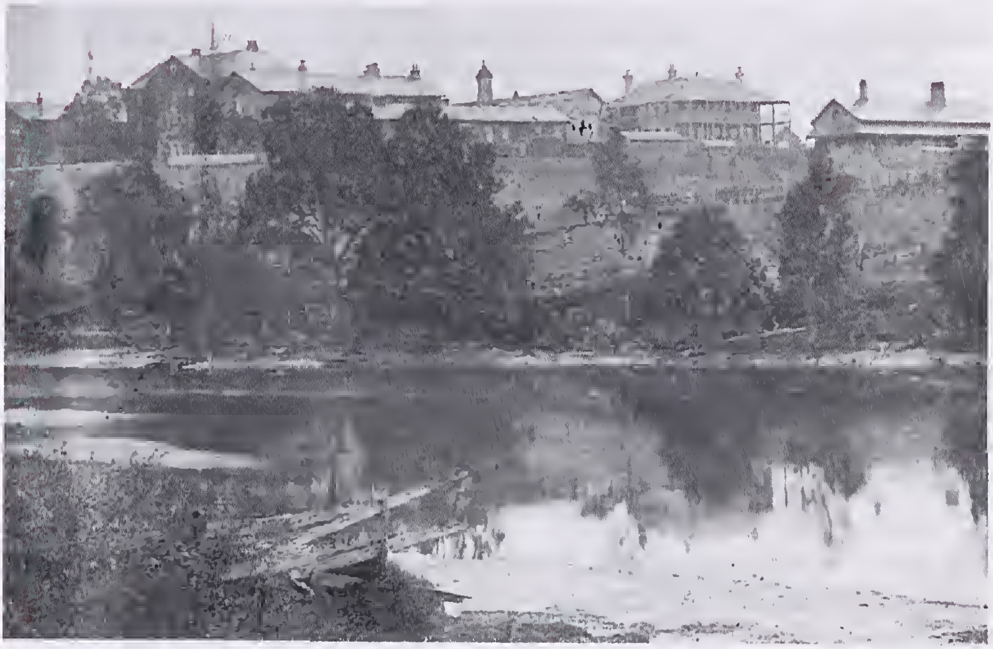


Fig. 5b. View of Protestant Orphan School, 1870s (Mitchell Library, State Library of New South Wales, GPO 1-06131). A young mangrove grows on the accreting mud along the foreshore in front of the Orphan School. This shoreline now has a complete fringe of tall mangroves. The Orphan School boatshed (in Fig. 4a) and elements of the former foreshore vegetation survive behind this fringe.

fringe of eucalypts, casuarinas and shrub species (Fig. 5a). Later pictures variously show the fringe as clumps and scattered trees (2:8, 10, 17) or relatively unbroken (2:15, 32). By about 1850, accumulation of sediment along the banks is obvious (2:17, 31) and in the 1870s an early photograph clearly shows a single young mangrove in the intertidal zone in front of the band of eucalypts and other terrestrial species (2:32, Fig. 5b). Today elements of the former waterfront fringe of terrestrial species still stand behind a tall belt of mangroves.

Discussion

Vegetation at the time of settlement

The combined written, pictorial and cartographic evidence builds a substantial, although incomplete, picture of the foreshores of the Parramatta River in the early years of settlement. Along the northern sandstone shoreline from Greenwich to Charity Point (and on the sandstone parts of the southern shores) rock outcrops and platforms were interspersed with sandy beaches (3:11, Campbell 1919, Cunningham 1966), backed by *Casuarina glauca* and moderate to steep slopes of sandstone eucalypt woodland. In the small narrow bayheads tributary creeks had built pockets of alluvium, beaches, limited mudflats and small areas of saltmarsh, reeds and rushes but few, if any, mangroves. On the south side from Balmain to Uhrs Point in the coves around the large embayments draining a largely shale catchment, were significant areas of intertidal mudflats and of low-lying alluvium covered in saltmarsh communities. There were patches of mangroves, particularly in the southeast of the coves and/or fringing the creeks but they did not form a consistent outer zone to saltmarsh.

From Homebush Bay upstream past Duck River erosion of the Wianamatta Shale had created broad areas of low-lying land, much of which flooded on spring high tides, and, like the southern bays downstream, large areas of inter-tidal mudflats not colonised by either mangroves or saltmarsh. Vegetation on the low-lying alluvium was dominated by extensive saltmarsh communities. Mangroves were present, at least along the Homebush Bay tributaries and on an island surrounded by mudflats (now part of the shoreline upstream of Wentworth Point) but there is insufficient evidence to determine their distribution at this time as far as Subiaco Creek. On slightly higher parts of the alluvium were groves of 'casuarina' and 'melaleuca scrub'.

Upstream from Subiaco Creek there is no evidence of mangroves in the early years of the colony. Here evidence indicates open eucalypt woodland with grassed understorey and well-spaced trees on raised alluvial banks, or mixed casuarina and eucalypt woodland with shrub understorey closer to the water's edge. Colonisation by mangroves appears to have begun in this part of the river in the latter part of the 19th century.

Post-settlement changes

Settlement along the river commenced at Parramatta in November 1788, Impacts included increased sedimentation, increased turbidity and changes in water quality with increased nutrient loading and other forms of pollution. As these accelerated, the wetland systems responded. Mudflats expanded in bays and along the margins of the river and by the late 19th century, mudflats were a dominant component of the intertidal zone (Figs 3a and 3b), along with saltmarsh.

Mangroves colonised upstream along shoreline not previously colonised, out onto mudflats and landwards into saltmarsh. There is evidence of mangroves beginning to appear in the upper river in the 1870s (Fig. 5b) and by the 1890s significant patches were established upstream from Duck River (Fig. 3b). By the 1930s mangroves in the southern bays were being targeted by local councils for reclamation (1:22). The Reclamation Act 1930 set up mechanisms by which reclamation could be approved, funded and the resulting land legally disposed. Recording of subsequent reclamation thus often describes areas reclaimed as mangrove swamps but the inference that mangroves were the pre-European vegetation, which remained intact until they were destroyed by reclamation, is a simplistic view of post-1788 impacts on these wetland systems. Using aerial photographs, Thorogood (1985) demonstrated that expansion of total mangrove area in Port Jackson-Parramatta River continued up until the 1950s with a 20% increase from 1930 to 1951, despite reclamations during this period.

Figs 3a and 3b show wetland vegetation 40–50 years earlier than previous mapping based on aerial photographs from the 1930s–40s. Whilst this cartographic evidence of wetland distribution is the most concrete and detailed available to date for the period prior to the 1930s, it represents only a snapshot in a possibly very dynamic system. However, there is some evidence, for example comparison of Figs 2 and 3b, that change in wetlands over the first 70–100 years may have occurred mainly as expansion of mudflats. Mangroves then expanded first onto mudflats and up river from the latter part of the 19th century (Fig. 3b) and into saltmarsh in the 20th century.

Although reclamation has been considered largely responsible for losses of extensive areas of wetland vegetation in most of the bays along the river (Lynch et al. 1976, Forbes and Shillington, 1987), comparison of Figs 3a and b with modern maps reveals that in many places the modern seawalled shoreline closely mirrors the low tide edge of the mudflats of the 1880s–90s. Areas filled were predominantly mudflats in the earlier reclamations of the late 19th and early 20th centuries. Later reclamations from the 1930s, such as at Hen and Chicken Bay, Homebush Bay and Duck River, affected large areas of saltmarsh. Mangroves were also affected but at least some of the mangroves destroyed during reclamation were of recent origin.

The mangrove referred to previously in this paper is the Grey Mangrove, *Avicennia marina*. *Aegiceras corniculatum* (Forsk.) Vierh., the River Mangrove was identified as abundant 'on the banks of the Parramatta River' in 1859 by William Woolls (1:19). However, of 25 specimens of *Aegiceras corniculatum* held by the National Herbarium of NSW, collected in the Sydney region from Broken Bay/Hawkesbury River to Port Hacking between 1887 and 1996, none are from the Parramatta River. Likewise, of seven specimens held by the Royal Botanic Gardens, Kew, England, collected in the same region from 1862–1984, none are from the Parramatta River (R. Chinnock, Australian Botanical Liaison Officer, Kew, pers comm., 17 Sept. 1999). Both collections include a specimen collected in 1802–05 by Robert Brown from 'Port Jackson', at that time a general term for the entire Sydney settlement.

Only one of the studies or listings reviewed for this paper lists *Aegiceras* as present in the 20th century (Clarke & Benson 1988). Benson (pers. comm., 24 June 1999) states he saw one plant at Bicentennial Park, Homebush Bay which was later destroyed by boardwalk construction. It was not found by later Homebush Bay studies (Webster & Kachka 1992, Kachka 1993, M. Burchett, UTS Sydney, pers. comm. 26 July 1999) but has recently been located in a small cluster at Bicentennial Park (Swapan Paul, Scientific Officer, pers. comm. 4 Feb. 2000) and at Duck River (P. Adam, pers. comm. July 2000). Although not common, River Mangrove is specifically listed for nearby estuaries, Brisbane Water, Hawkesbury River, Pittwater, Botany Bay, Georges River and Port Hacking (West et al. 1985) and for Lane Cove River (Lane Cove Council 1998).

Mangroves, among other inter-tidal vegetation, were burnt for barilla, an alkaline ash used for soap manufacture in Australia from 1810 to about 1850. However, although there is evidence of harvesting mangroves at Hen and Chicken Bay for timber in the early 19th century (1:14), there is no evidence for other harvesting in the Parramatta River. Most of the soap factories were at Botany Bay (Bird 1981) and harvesting may have been focussed there. Harvesting is unlikely to have affected later distribution as *Avicennia marina* colonises and regenerates strongly in the Parramatta River (Clarke & Benson 1988).

Lack of available inter-tidal mudflats is unlikely to account for the apparent mangrove distribution at the time of European settlement, given the extent of open mudflats at Homebush Bay, for example, at this time. However, sedimentation along the banks of the upper river may have contributed to their expansion there by the late 19th–early 20th century. Increased nutrients from the effects of settlement: clearing, agriculture, domestic animals and urbanisation, may also have rendered some inter-tidal areas more suitable for mangrove colonisation than they had been prior to settlement (Saintilan & Williams 1999). Other changes in conditions possibly influencing the relative distribution of mangroves and saltmarsh in this system are a reduction in the freshwater component of the river towards Parramatta with the construction of the first weir there in 1857 (SMEC 1976) and reduced salinity in saltmarshes due to increased precipitation on the east coast of Australia since 1945 (Saintilan & Williams 1999).

Planning and conservation

Studies using the earliest aerial photographs as the primary information for the 'former extent' of wetland vegetation of the Parramatta River, may be fundamentally flawed if this is taken to represent distribution earlier than the 1930s–40s, given 140 years of change in the river system to that time. Planning studies which produce development controls or recommendations for enhancement of foreshore areas and restoration of 'natural' vegetation communities based on a datum point in the 1940s may likewise suffer from erroneous assumptions.

The availability of aerial photographs, Lynch et al's (1976) unsourced statement and ecological inference regarding the historical distribution and nature of wetland systems of the Parramatta River have had a significant influence on foreshore planning and restoration activity. Mudflats, or gaps in the mangrove belt along the shoreline have been taken to mean that mangroves have been destroyed. New mangrove growth has been taken to indicate 'regenerating' mangroves (Register of the National Estate n.d. c, e, DEP 1986b, 1986c, Powell 1987, Gutteridge, Haskins & Davey 1991) and bare mudflats and gaps have been recommended for revegetation or regeneration with mangroves to restore the 'natural' foreshore vegetation (SPCC et al. 1983, DEP 1986d, Moss 1987, Clouston 1995, Pittendrigh, Shrinkfield, Bruce 1996, EDAW and Environmental Partnership 1997).

This examination of the available historical evidence indicates assumptions that Grey Mangrove, *Avicennia marina*, was a dominant component of the pre-settlement Parramatta River wetlands are not well-founded. Saltmarsh, including reed and rush communities, appears to have been more extensive and these communities have suffered the most severe reductions in area as a result of settlement (Thorogood 1985, Burchett & Pulkownik 1996). The casuarina/ melaleuca associations, although formerly perhaps less extensive than saltmarsh, have also become rare. By contrast mangroves expanded significantly onto rapidly expanding mudflats in the bays and up river from approximately the 1870s to the 1950s and into saltmarsh, at least from the 1930s (Clarke & Benson 1988), until reclamation impacted their area. A similar pattern of expansion has been described for the Lane Cove River (McLoughlin 1987).

Williams and Watford (1997) found expansion along the shoreline, downslope and upslope occurred from existing mangrove stands in Berowra and Marramarra Creeks, tributaries of the Hawkesbury River, between 1941 and 1992. Mangrove extension into saltmarsh in the Sydney region in the 20th century has also been noted in Botany Bay (Mitchell & Adam 1989), Hawkesbury River (Saintilan 1997), and the Hunter River (Buckney 1987). Further afield, studies using aerial photographs are demonstrating mangrove transgression in many coastal estuaries of south-eastern Australia over the last 50 years, but not in every estuary or in all creeks within an estuary (Saintilan & Williams 1999). However, discussion of the mechanisms causing mangrove expansion into saltmarsh is hampered by the relatively short time frame of the aerial photographs available.

Saltmarsh has been demonstrated to be important as bird habitat in the Hunter estuary (Buckney 1987) and Homebush Bay (Straw 1996) and mudflats in Homebush Bay and Hen and Chicken Bay (Taylor & Hutchings 1996). In the Parramatta River large numbers of ducks and other waterbirds were noted in the Homebush Bay/Newington area, where there were large areas of saltmarsh and mudflats, by Richard Atkins in the 1790s and Campbell (1919) and Garling (1924) in the 1850s. The listing of Parramatta River wetlands on the Register of the National Estate (n.d., a–g)) includes their important role as habitat for migratory birds covered under international agreements.

Clarke and Benson (1988) and Burchett and Pulkownik (1996) noted the significant loss of saltmarsh at Homebush Bay and Adam (1996) of saltmarsh in the Sydney region. Saintilan and Williams (1999) note its significant loss in other estuaries of the east coast. Recent conservation and rehabilitation work in the Homebush Bay and nearby Newington wetlands associated with the Olympic Games site, has focussed on monitoring and methods for saltmarsh re-establishment (Burchett & Pulkownik 1996), and Leichhardt Council (1999) has undertaken a small saltmarsh revegetation program at its Federal Park in Annandale. Elsewhere there has been little recognition of losses in saltmarsh along the river, and there is still little consideration or effort given to the replacement/replanting of saltmarsh, rush and reed communities while the focus remains on mangroves or while the perception that saltmarsh only existed in narrow bands behind mangroves persists (DEP 1986c). The more recent foreshores improvement plan for Duck River (EDAW 1997), which considers re-establishment of salt marshes as 'an appropriate conservation priority', is an exception.

Ongoing loss of saltmarsh also has significant implications for management of mangrove seedling invasion of the existing small saltmarsh zones in heavily impacted areas such as the Parramatta River. In many parts of Sydney *Pittosporum undulatum*, a species native to wetter bushland environments, is regularly culled from dry sclerophyll areas where absence of fire allows its invasion and expansion, threatening the viability of those communities. Should mangroves be similarly culled where they invade saltmarsh, under what conditions and in which areas?

This paper has brought together a variety of historical evidence to shed light on the nature of wetland distribution on the Parramatta River at the time of European settlement and subsequent changes up to the 1930s when aerial photography provides more consistent data. The study illustrates the importance of both location specific studies and the role of historical evidence in reconstructing the former distribution of vegetation to provide a firmer basis for conservation (Lunt 1998), management and, if appropriate, restoration.

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c) Meadow Bank Foreshore wetland, Meadowbank NSW, File No.019257.
d) Yaralla Bay wetlands, Concord West NSW, File No.019259.
e) Majors Bay wetlands, Concord NSW, File No.019260.
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Surveys of areas having potentially high botanical diversity near Pooncarie, South Far Western Plains

AnneMarie Clements, Tony Rodd, Rosalind J. Moore, Adele G. Crane and John Simpson

Clements, AnneMarie, Rodd, Tony, Moore, Rosalind J., Crane, Adele G. (Anne Clements and Associates Pty Ltd, P.O. Box 1623, North Sydney, NSW Australia, 2059) and Simpson, John (RZM Pty Ltd, 250 St. Georges Terrace, Perth, W.A. Australia, 6000) 2000. Surveys of areas having potentially high botanical diversity near Pooncarie, South Far Western Plains. Cunninghamia *6(3): 611–643.* Vegetation in the remote Pooncarie region of south-western New South Wales was surveyed in the springs of 1995 and 1997 following rain. One area of 100 km^2 was examined in 1995 and three zones totalling 468 km^2 were surveyed in 1997. Sampling in 1997 targeted sites removed from artificial watering points and human habitation. Two of the three areas examined in 1997 were remote from access tracks. These areas were assumed to be relatively free from human impacts, have reduced grazing pressures and hence higher plant species diversity and a greater conservation value than areas which were closer to human disturbance or artificial water supplies.

Both the 1995 and 1997 data were statistically analysed using a hierarchical agglomerative clustering technique. Three broad vegetation groupings were discerned, Mallee dune crests, Lake beds and Mallee with *Trioda scariosa.*

Species richness for the area was high with 36% of the total species recorded being ephemerals. Exotic species were found in almost all the sampling locations, accounting for approximately 10% of the total species diversity. As exotic species are indicators of disturbance, it can be concluded that disturbance, or its influence, is widespread, but relatively minimal, throughout the area. Scats of native and exotic grazing animals were found throughout the survey areas.

A total of 375 species (328 native and 47 exotic) from 64 families/subfamilies was recorded in both surveys. In the 1995 survey, 263 species (226 native and 37 exotic) from 57 families/subfamilies were recorded. In the 1997 survey, 311 species (277 native and 34 exotic) from 61 families/subfamilies were noted. In terms of species of conservation significance, two species of national, five species of state and 21 species of regional significance were recorded. One new species was recorded for New South Wales and 25 new species were recorded for South Far West Plains botanical division.

Introduction

The vegetation of some of the most remote areas within the South Far Western Plains botanical division of New South Wales, east of the Darling River and west of Lakes Garnpung and Mungo (Fig. 1), was surveyed in the springs of 1995 and 1997 following rains. The November 1995 survey followed 52.6 mm of rain in October 1995. Prior to the September/October 1997 survey, 31 mm fell in August (Fig. 2). Wellard (1987) and

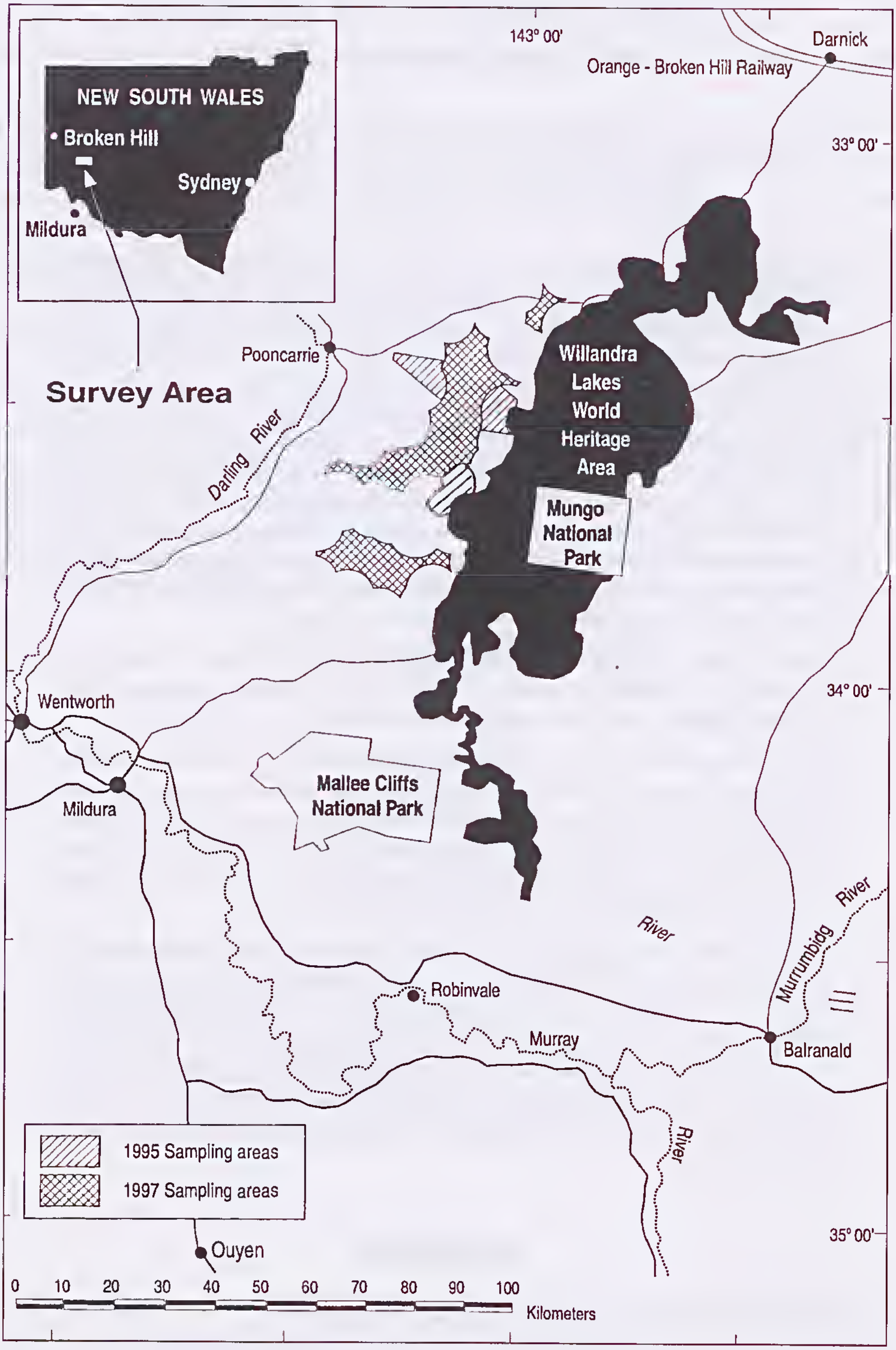

Fig. 1. Location map of 1995 and 1997 sampling areas.

Robertson (1987) found that rainfall in the previous six months explained 70% of the biomass variation in arid areas. In the repetitive sampling of mallee vegetation in western New South Wales from 100 m × 40 m quadrats, Fox (1990) found that both the number and composition of species recorded varied as a function of seasonal rainfall.

The initial survey in November 1995 was centred on an area surrounding 629000N 680000E (Australian Grid Map) covering about 100 km² on the western shore and parts of the dry lake bed of Lake Garnpung. There was minimal human impact and few artificial watering points in this area. The high species diversity and low weed occurrence were likely to be related to the relatively low intensity of grazing (Landsberg et al. 1997). Dr J. Landsberg, Wildlife and Ecology, CSIRO, Canberra and Professor T. Dawson, School of Biological Sciences, University of New South Wales (personal communication, March 1997) both estimated that feral goats had a grazing impact range of 5 km from watering points. In an attempt to survey ungrazed vegetation in the region, three areas, more than 5 km from artificial watering points, were targeted for investigation in the 1997 survey. These areas are within the Australian Map Grid rectangle 625000–632000N 640000–690000E (Fig. 3), at an elevation of approximately 70–120 m:

- Northern Area — 18 km² (631000N, 690000E) on Pan Ban and Garnpung Stations
- Central area — 300 km² (L-shaped 628000N, 647000–670000E; 628000–635000N, 670000E) on Lethero, Balranald Gate, Pt Balranald Gate, Birdwood, Yarraman and Garnpung Stations
- Southern area — 150 km² (626500N, 647000–670000E) on Studley, Lethero, Murragi, Petro and Arumpo Stations.

Climate

The climate of western NSW is semi-arid to arid. The features of the region are low, unreliable and highly variable rainfall, low humidity, high summer temperatures and evaporation rates, frequent dry periods lasting from several months to a number of years and occasional floods with rainfall occurring as intense storms (Date 1992).

In the study region, the average annual rainfall varies between recording stations within a narrow range of 234–275 mm, with a mean of 254 mm for ten stations in the vicinity. The average rainfall is uniformly distributed through the year with a 3% mean difference between summer and winter rainfall. Annual evaporation is about eight times the average rainfall (Dare-Edwards 1979).

Temperatures are consistently hot in summer and mild in winter (Date 1992). The monthly maximum temperature is 33.9°C in January and the monthly minimum is 4.7°C in July (Menindee Post Office meteorological station #047019) (Bureau of Meteorology 1988).

Soils

The 1995 survey sampled vegetation from six of the land systems described by Green (1980) in the Pooncarie 1: 250 000 sheet, namely: Arumpo Dunefields (Ap), Leaghur

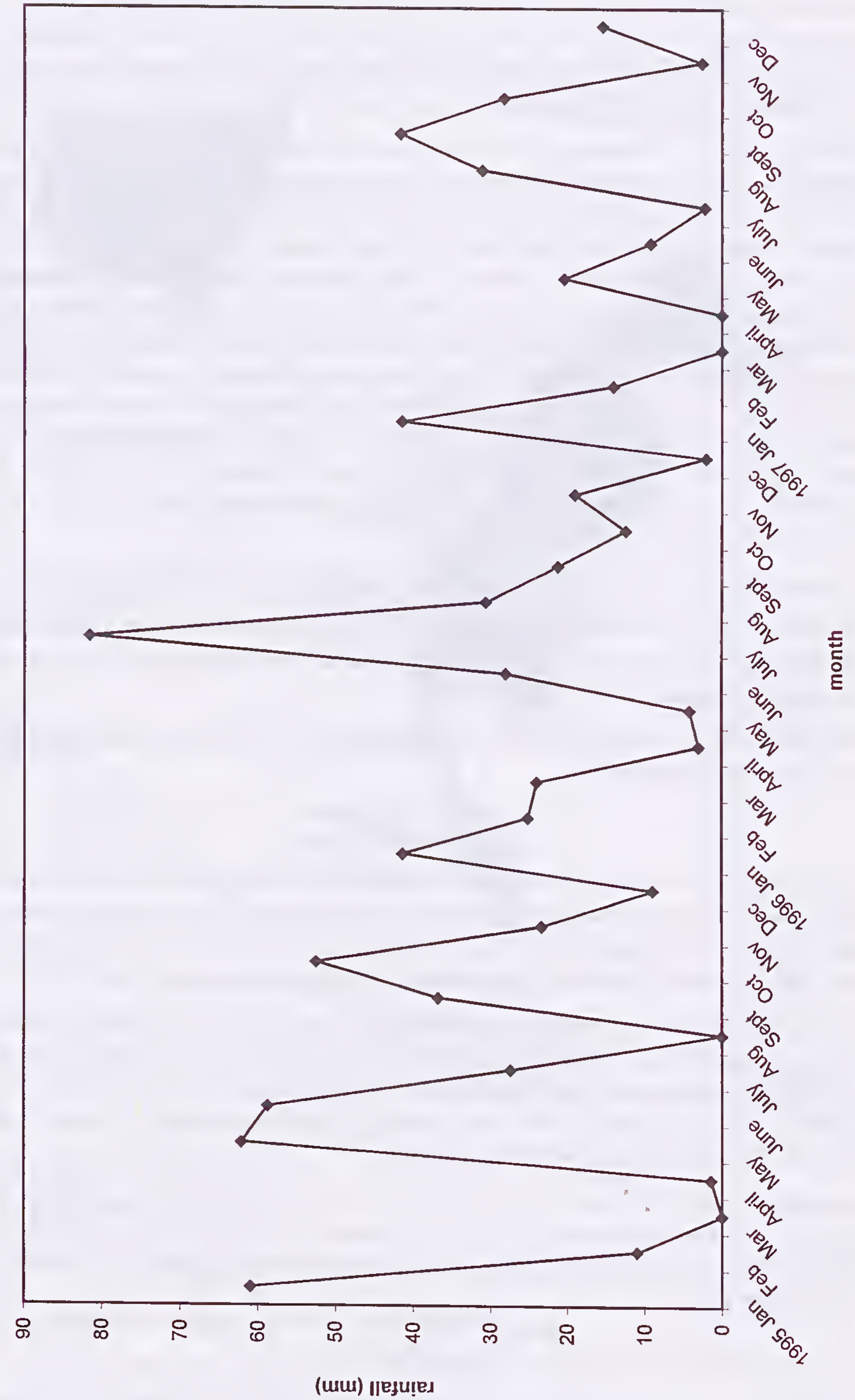

Fig. 2. Pooncarie: monthly precipitation January 1995–December 1997.

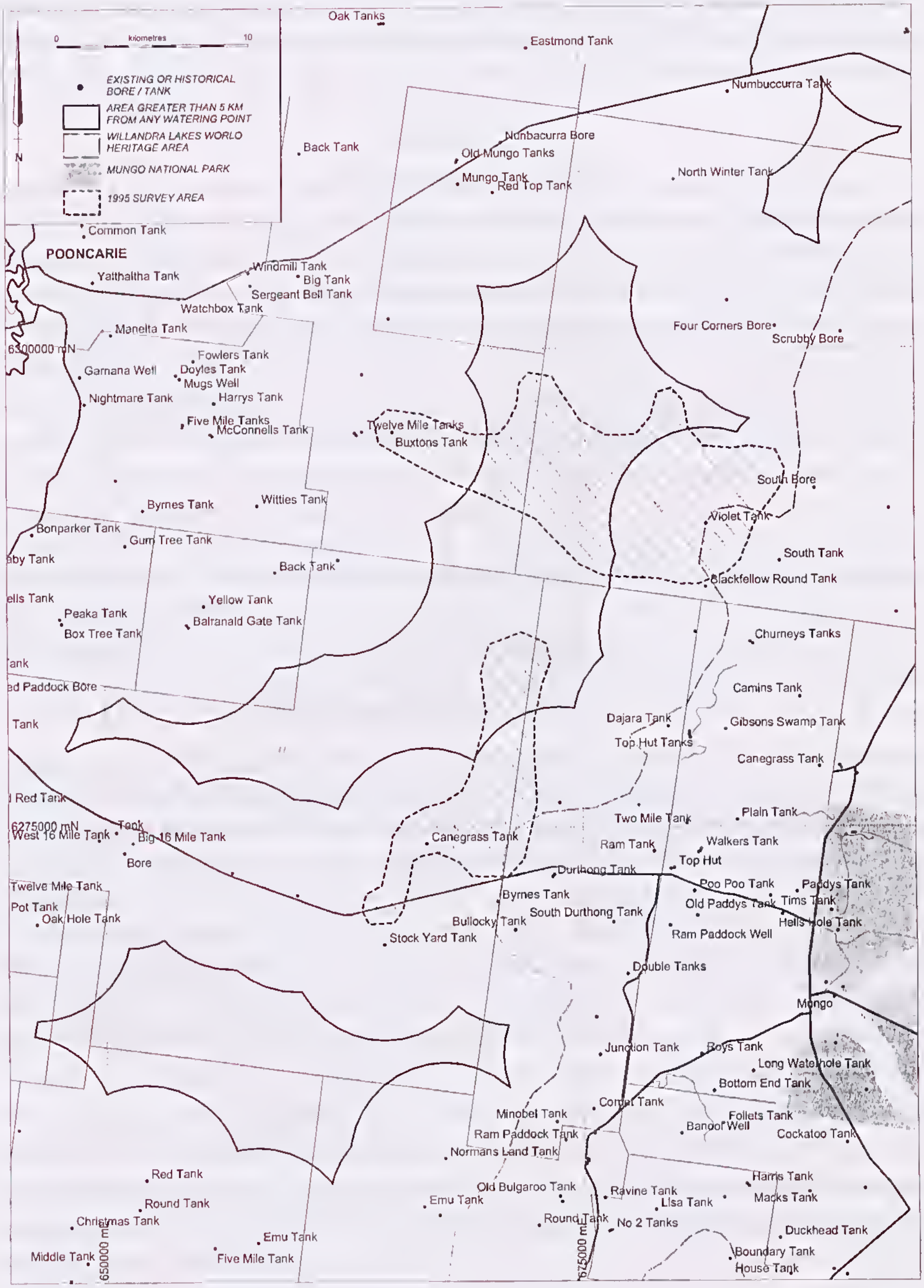

Fig. 3. Location of 1995 and 1997 survey areas in relation to artificial watering points.

Dunefields (Lh), Mandelman Dunefields (Mm), Overnewton Sandplains (Ov) and Garnpung Playas and Basins (Gn). The 1997 transect survey, although covering a greater area, only sampled flora from Ap, Mm and Mungo Playas and Basins (Mu) systems (Appendix 1). Leaghur Dunefields (Lh), Gn and Ov systems were sampled in spot surveys during 1997. Mandelman Dunefield is the only land system that occurred in both the 1995 and all 1997 survey areas.

Land use

The first wave of human occupation of the mallee lands of the South Far Western Plains Area dates from 50 000–40 000 years BP. Intervening arid phases with dune destabilisation and xeric conditions probably prevented any continuous occupation (Harris 1990). Evidence of ancient human occupation is found in the high shoreline gravels on Outer Arumpo and on the western side of all major lakes. In the dry lakes of the Willandra Creek system, there is evidence of a core and scraper industry associated with fires, burnt bones and unionid shells, coinciding with periods when lake water and aquatic life were present (17 000–32 000 years BP) (Bowler 1971).

In the 1870s, European occupation of the hinterland became possible with the introduction of well, bore and tank sinking techniques (Palmer 1991). Pastoral and agricultural activities introduced to the area expanded, leading to over-grazing, removal of vast areas of native vegetation and encroachment of exotic species of both fauna and flora (Webb 1998). The first reports of rabbit invasions occurred in 1884 concurrent with records of the proliferation of inedible native shrubs *Dodonaea* spp. (Hopbush), *Senna* spp. (Punty Bush) and *Eremophila sturtii* (Turpentine). Legislation in 1884 divided runs into term leasehold areas (Palmer 1991).

The 1901 New South Wales Royal Commission into the conditionof crown tenants in the Western Division of New South Wales listed seven principal factors contributing to widespread depression and general unprofitibility of the pastoral industry. The majority of these were based on the unsuitability of the environment for European farming practices, namely low rainfall, rabbit plagues, overstocking, sandstorms, growth of non-edible scrub, fall in prices and want of sufficient area (Noble 1997). Vast areas were windswept, with sand drifts covering fences, water troughs, stockyards and earthen dams. Extensive areas of perennial shrubs, notably the *Atriplex* spp. (Saltbush) and *Maireana* spp. (Bluebush), were destroyed, often on the more erodible soils (Palmer 1991).

Currently, grazing on uncleared land is the major land use. There are some short-rotation pastures and crops. These have varying success dependent on the erratic climate of the mallee land systems (Calder 1990). Condon (1986) suggested that there has been a major recovery since the 1940s and early 1950s with the frequency of these events having declined. He attributes this decline to the tight controls on land use in the Western Division of New South Wales exercised by the Western Lands Commission. Limitations are placed on the proportion, total area and pattern of clearing on any grazing leases. Restrictions on the clearing of sandhills have contributed to the relatively small proportion of mallee being cleared in the Western Division of New South Wales in recent years. The Western Division occupies an area of 320 000 km². Budd et al. (1990) noted that of the 28 783 km² of mallee in New South Wales (Fitzpatrick 1982), 22 940 km² (80%) occur in the Western Division within the Murray Geological Basin. This represents approximately 7% of the area of the Western Division. The vast majority of this area is Crown Land, held under pastoral leases administered by the Department of Land and Water Conservation. In the mid to late 1980s approximately 8% of the Western Division was under the control of National Parks and Wildlife Service (Pickard 1987).

Previous flora surveys

One of the earliest surveys of the vegetation of south-western NSW (Turner 1904) describes the area between 141–147°E and between 33°S and the NSW-Victorian border. The current study area is located at approximately 143°E, 33.4°S. In Turner's accompanying tables, 147 members of the Compositae (family Asteraceae), including 23 exotics were listed.

The 1945 vegetation map (1: 1 000 000) of western NSW (Beadle 1948) is the most extensive representation of vegetation of the mallee areas of NSW. The vegetation communities identified by Beadle in the region were:

Atriplex vesicaria Association (Saltbush)

Kochia pyramidata (now *Maireana pyramidata*)-*Kochia sedifolia* (now *Maireana sedifolia*) Association (Bluebush)

Casuarina-Heterodendrum (now *Alectryon*) Association (Belah and Rosewood)

Eucalyptus oleosa-Eucalyptus dumosa Association (mallee)

Porteners and Ashby (1996) describe the vegetation of the Pooncarie 1:250 000 map sheet recording the vegetation communities, native plant species with descriptions of significant species and plant uses. For the Pooncarie 1: 250 000 sheet, Porteners et al. (1997) recognise 18 plant communities and record 330 species of vascular plants. Exotics accounted for 40 (12%) of the species. Their sampling sites were close to primary and secondary roads. The composition and extent of the present native vegetation was mapped from 1: 100 000 Landsat images and ground-truthed from 110 sites each of 1000 m² (50 m × 20 m). They noted that during their survey (May 1994 to April 1995) the region was undergoing a severe drought.

In the area covered by the 1995 survey, Porteners et al. (1997) identified five plant communities (Irregular Dune Mallee, Linear Dune Mallee, Belah-Rosewood, Belah-Rosewood/Lunette Shrubland and Open Area/Scattered Belah-Rosewood).

In the 1997 survey target areas, four plant communities were identified (Irregular Dune Mallee; Linear Dune Mallee; Belah-Rosewood and Black Bluebush/Disturbed Shrubland Complex).

The area of Irregular Dune Mallee (3a) south east of Pooncarie, extending over parts of Lethero, Petro and Arumpo Stations and known locally as 'No Man's Land' was identified as one of key conservation value (Porteners et al. 1997). This area was targeted in our 1997 survey.

In the 1: 250 000 land system mapping of the Western Division (Walker 1991), the vegetation was categorised into broad vegetation types, resulting in a vegetation map of low resolution (Fox 1984).

Mungo National Park, adjoining the study area, was surveyed by by Westbrooke and Miller (1995) in September 1992 following rain. Two hundred and thirty-five plant species were noted of which 26% were exotic. Morcom and Westbrooke (1990) mapped the vegetation of Mallee Cliffs National Park, located to the south of the study area (Fig. 1). They recognised 215 plant species, 20% of which were exotic.

Methods

In November 1995, the vegetation from 56 transects and 68 spot locations was surveyed. The majority of transects used in the 1995 survey were 100 m × 10 m, consisting of ten contiguous 10 m × 10 m quadrats. Transects 50, 54, 55 and 56 were all half this size, 50 m × 10 m (consisting of five 10 m × 10 m quadrats), the stands of homogeneous vegetation being of a smaller size at these locations. During the 1995 survey species-area curves were used to determine the minimum area required to adequately sample the vegetation. This area was found to be 500–600 m^2.

The relative frequency of plant species was objectively assessed by recording the presence/absence of each species in each of the contiguous 10 m × 10 m quadrats, though species not exceeding 2 m height were scored only for a 5 m × 5 m sub-quadrat in each quadrat. In each 10 m^2 quadrat, the numbers of individuals over 2 m high of each species were noted. In both surveys, transect sampling was supplemented by spot recordings.

Target areas for the 1997 survey were selected on the basis of being at a distance of over 5 km from known artificial watering points. The transect sampling area chosen was consistent with the 1000 m^2 sampling area size (50 m × 20 m) used in the 1: 250 000 Pooncarie sheet survey (Porteners et al. 1997). Transects of 100 m × 10 m were examined, homogeneity of vegetation recorded in the transects was assessed visually at the time of sampling, so that each transect should sample only one vegetation type. 'Spot' recording sites of 10 m radius (sampling area 300 m^2) were also examined.

In the 1997 survey, the methods were as used in 1995. Data from the northern, central and southern target areas were collected.

For the northern area, vegetation was sampled at a total of 27 locations, with 22 transects (57–66, 97–108) and five spot locations (A69, A79–A81 and A85). All spot locations and 20 of the 22 transects were within 1 km of the northern target area.

In the central area, vegetation was sampled from 44 sampling locations, with 30 transects (67–96) and 14 spot locations A70–A78, A82–A84, A86–A87). All but one of the transects and 11 of the spot locations were within 1 km of the central target area.

For the southern area 22 transects (109–130) and 40 spot locations (A88–A94, A96–A106, A109–A130) were surveyed. Spot locations A109–A130 were within 100 m of transects. Of the 62 locations, 19 transects and 30 spot locations were within 1 km of the southern target area.

Boundary and exploration tracks were used to identify exact locations during the 1995 survey. In 1997, sampling locations were recorded using a Garmin 38 GPS. In the northern and the central areas sampling was evenly spread over the area, whereas in the southern area, sampling was adjacent to access tracks. Sampling in the central area was limited to an individual land holding. Geographical co-ordinates for both the 1995 and 1997 transect and spot locations are shown in Appendix 1.

Due to the remoteness of the study area and small size of many of the plants to be identified, samples of all plants in each quadrat were collected and bagged separately, except for very common species which were collected at least once per transect. All bagged specimens were checked before data entry and any species of conservation significance sent to the Royal Botanic Gardens, Sydney for further confirmation. During 1997, in addition to the vegetation study, animal scats were collected from the transects. The scat data were supplemented by spot recordings allowing for an objective assessment of the presence of animal species.

Results

Flora observations

A total of 375 species (328 native and 47 exotic) were recorded in the 1995 and 1997 surveys. In the 1995 survey, 263 species (226 native and 37 exotic) were recorded. In 1995, the number of species per transect ranged from 21 (transect 34) to 57 (transects 1 and 21) (Appendix 1) with an average of 39 species of which 89% were native. Two transects recorded zero exotics.

Of the total 311 species (277 native, 34 exotic) recorded in the 1997 survey for the northern, central and southern areas, the following were observed in the individual areas:

Northern area: 167 species (145 native and 22 exotic). The number of species per transect ranged from 13 (transect 62) to 54 (transect 104) (Appendix 1) with an average of 33 species of which 31 (94%) were native. The transects with the greater number of species have the higher percentages of exotic species. In this relatively small area only two of the 22 transects had zero exotic species.

Central area: 218 species (199 native and 19 exotic). The number of species per transect ranged from 19 (transects 69 and 79) to 57 (transect 86) (Appendix 1) with an average of 34 species per transect of which 32 (95%) were natives. In 10 of the transects (33%), there were no exotic species recorded.

Southern area: 233 species (210 native and 23 exotic). The number of species per transect varied from 13 (transect 126) to 58 (transect 128) (Appendix 1) with an average of 33 species of which 31 (94%) were natives. No exotic species were recorded in 50% of the southern area transects.

The percentages of exotic species found in the 1997 survey were lower than those noted by Westbrooke and Miller (1995) in Mungo National Park (26%), and Morcom and Westbrooke (1990) in Mallee Cliffs National Park (20%), indicating that the remoteness of the 1997 target areas had aided the conservation of the indigenous flora.

Ephemerals

These are described in *Flora of New South Wales* (Harden 1990–1993) as annual herbs, except for a very few that are described as annual or perennial. In the arid western New South Wales environment, a species described as annual or perennial would most commonly behave as an annual. A total of 136 species of ephemerals was recorded in the 1995 and 1997 surveys (Appendix 2), accounting for 36% of the species. Of these 106 (78%) were native and 30 (22%) exotic. Ephemerals formed 36% of the total flora in both surveys. In 1995 there were 95 ephemeral species recorded, 22 (25%) of which were exotics. The 1997 survey recorded 112 ephemeral species, of these, 25 (22%) were exotic.

The number of ephemerals varied between the three 1997 survey areas (Appendix 2). In the northern and central areas compared with southern area there were higher percentages of ephemerals (47 and 42% compared with 37% respectively) and lower total numbers of species recorded (167 and 218 compared with 233 respectively).

Conservation significance

Communities

No Endangered Ecological Communities, as defined in the NSW *Threatened Species Conservation (TSC) Act 1995*, were noted in either the 1995 or 1997 surveys. Although there are existing mallee reserves in New South Wales, there has also been widespread retention of mallee on Crown Lands held as Western Lands Leases, in part to reduce the risk of dryland salinity and soil loss in agricultural areas (Brickhill 1988).

The *Eucalyptus socialis-Eucalyptus dumosa-Eucalyptus gracilis-Eucalyptus polybractea* mallee vegetation community is found in nine conservation reserves (Yathong, Nombinnie, Kajuligah, Round Hill, Tollingo and Loughnan Nature Reserves; Mallee Cliff, Mungo and Cocoparra National Parks), representing a large part of the range of the biogeographic regions in which the community occurs (Specht et al. 1995).

Species

In the 1995 survey, twelve species of conservation significance were recorded; one species at a national (ANZECC 1997, Briggs & Leigh 1996) and state (TSC Act 1995) level, namely *Brachycome papillosa*, one species, *Swainsona sericea* (formerly *Swainsona oroboides* subsp. *sericea*) under a state Vulnerable listing (TSC Act 1995) and twelve at a regional (Pressey et al. 1990) level: *Atriplex nummularia, Blennodia canescens, Boronia caerulescens, Brachycome papillosa, Calandrinia volubilis, Exocarpos spartens, Grevillea pterosperma, Nicotiana occidentalis* subsp. *obliqua, Poa fax, Podotheca angustifolia, Sida* sp. aff. *corrugata* and *Swainsona sericea*.

Nineteen species of conservation significance were recorded in the 1997 survey, including one at national (ANZECC 1997, Briggs & Leigh 1996) level, namely *Lepidium monoplocoides*; four at state (TSC Act 1995) level namely: *Acacia acanthoclada, Lepidium monoplocoides, Santalum murrayanum* and *Swainsona sericea* and nineteen at a regional (Pressey et al. 1990) level, namely: *Acacia acanthoclada, Atriplex nummularia* (includes

Atriplex nummularia subsp. *omissa* in Harden (1990–1993)) *Atriplex vesicaria* subsp. *macrocystidia*, *Blennodia canescens*, *Boronia caerulescens*, *Calandrinia volubilis*, *Ceratogyne obinoides*, *Eucalyptus porosa*, *Exocarpos sparteus*, *Gahnia lanigera*, *Grevillea pterosperma*, *Lepidium monoplocoides*, *Menkea australis*, *Nicotiana occidentalis* subsp. *obliqua*, *Podotheca angustifolia*, *Santalum murrayanum*, *Sida* sp. aff. *corrugata*, *Swainsona sericea* and *Velleia arguta*. In the southern area twelve species of conservation significance were recorded, eleven species of conservation significance were recorded for the central area, and four species of conservation significance were recorded for the northern area (Table 1).

New records for New South Wales

No new records for New South Wales were noted in 1995. In the 1997 survey, one new record for New South Wales was found, namely *Lasiopetalum behrii*. A specimen has been lodged with the National Herbarium of NSW, Royal Botanic Gardens, Sydney.

Lasiopetalum behrii, a stiff-leaved shrub to 1.5 m high, flowering July to October (Jessop & Toelken 1986), was recorded at spot location A114 in the southern area in the 1997 survey. This species has been recorded by Willis (1973) for the region of north-western Victoria approximately north of Horsham and west of Swan Hill. Jessop and Toelken (1986) record *Lasiopetalum behrii* in the following botanical regions of South Australia: Flinders Ranges, Eyre Peninsula, Northern Lofty, Murray, York Peninsula, Southern Lofty, South Eastern and Kangaroo Island. These regions are all in the south-east quarter of that state.

Species not recorded by Porteners et al. (1997) and/or previously unrecorded for the South Far Western Plains botanical division

Our surveys found 74 species not listed by Porteners et al. (1997), doubtless a result of the better rainfall preceding our visits and the more extensive sampling of areas away from roads. In addition, 25 species not recorded by Harden (1990–1993) as occurring in the South Far Western Plains botanical division were noted (Table 2). Some species fell into both these categories, so that the total number of additional species records was 78.

Numerical analysis of the transect data

The combined data from 1995 and 1997 were numerically analysed using PATN (Belbin 1995). The transects were grouped using a hierarchical agglomerative clustering technique with a Bray-Curtis similarity measure of the abundance (0–10) of species within each transect. The estimate is based on the presence/absence of plant species in quadrats of the transects.

Three broad groupings were identified, namely:

Group 1 Mallee dune crests, mallee with *Callitris* spp. and lake shore with sand overblow (transects 9, 40, 42). This group was well represented in the 1995 survey area, with 22 of 56 transects. In the 1997 survey it occurred in the northern area (8 of 22 transects), in the central area (3 of 30 transects), but not in the southern area.

Table 1. Species of conservation significance recorded in 1995 and 1997 at the sampling locations

1995 : 1995 transects/points
N : northern 1997 transects/points
C : central 1997 transects/points
S : southern 1997 transects/points

Species	Location	National ANZECC (1997)	ROTAP (1996)	State TSC Act (1995)	Regional Pressey et al. (1990) category	priority
	S: 124, A96, A126	-	-	E	3B	4
Atriplex nummularia (includes *Atriplex nummularia* subsp. *omissa* in Harden 1990–1993)	1995: 11, 47 C: 78	-	-	-	3A	3
Atriplex vesicaria subsp. *macrocystidia*	C: 78 S: 128, 130, A105	-	-	-	4A	4
Blennodia canescens	1995: 6 N:58, 97	-	-	-	3B	4
Boronia caerulescens	1995: 7, 15, 26, 27 S: A88	-	-	-	3B	4
Brachycome papillosa	1995: A59, A60	V	3V	V	2	2
Calandrinia volubilis	1995: 11, 13, 28, 32, 54 C: 78 S: 130, A105	-	-	-	3A	3
Ceratogyne obinoides	C: 88 S: 110, 111, 113, A116	-	-	-	3B	4
Eucalyptus porosa	S: A92	-	-	-	3B	4
Exocarpos sparteus	1995: A10, C: 87, A77 N: 104	-	-	-	3B, 4A	4
Gahnia lanigera	S: 115, 116, 120	-	-	-	3B	4
Grevillea pterosperma	1995: 18, 36, 54 C: 67, 68, 79, A70 S: 121, 123, A120	-	-	-	3B	4
Lepidium monoplocoides	C: A82	E	3ECi	E	3A	2
Menkea australis	N: 61 C: 74, 75, 84 S: 113, 115, 117, 120, 123, 124, A116	-	-	-	3B	4
Nicotiana occidentalis subsp. *obliqua*	1995: 1, 4, 19, 21, 23, 27, 28, 29, 30, 32, 33, 39, 40,	-	-	-	3B	4

Species	**Location**	**National ANZECC (1997)**	**ROTAP (1996)**	**State TSC Act (1995)**	**Regional Pressey et al. (1990) category**	**priority**
	42, 44, 56, A1, A25, A30, A31, A33, A38, A40, A45, A48, A49, A62, A64, A65 C: 88, 94, A75 N: 66, 97, 98, 99, 107, A85 S: 110, 123, A110					
Poa fax	1995: 11, A58	-	-	-	3B	4
Podotheca angustifolia	1995: 14, 28, 29, 46, 49, 53, 54, A10, A41, A43, A51, A63 C: 87 S: 110, 111, 113	-	-	-	3B	4
Santalum murrayanum	N: 62	-	-	E	3B	4
Sida sp. aff. *corrugata*	1995: 3, 45 C: 89	-	-	-	3B	4
Swainsona sericea (formerly *Swainsona oroboides* subsp. *sericea*)	1995: 21, 35, A32, A34, A45 C: A75			V preliminary	4B	4
Velleia arguta	S: A106	-	-	-	3A	3

Key for Table:

National
ANZECC (1997)
E: endangered

ROTAP (Briggs & Leigh 1996)
3: distribution of >100 km
E: endangered
V: vulnerable
C: present in a conservation reserve
i: inadequately conserved

State
TSC Act (1995)
E: endangered
V: vulnerable

Regional
Pressey et al. (1990)
Categories
1 occurring only in the Western Division with a restricted distribution
3 restricted distribution in the western Division and also occurring interstate:
  A: small range and/or few records interstat
  B: wide range and/or many records interstate
4 disjunct occurrences in the Western Division
  A: main population interstate
Priorities
1 protection measures in the Western Division will completely determine the survival of these taxa nationally
2 protection measures in the Western Division will be a very important contribution to conservation of the taxa throughout Australia
3 conservation of the species in the Western Division will influence its overall survival
4 protection in the Western Division is desirable to conserve genetic variation within the ranges of these taxa

Table 2. Species not recorded by Porteners et al. (1997) and/or not previously recorded for SFWP (South Far Western Plains) as listed in Harden (1990–1993)

New SFWP	Botanical name	When Found
Yes	*Acacia havilandiorum*	97
Yes	*Aira caryophyllea*	95, 97
-	*Amphipogon caricinus* var. *caricinus*	95, 97
Yes	*Amyema cambagei*	97
Yes	*Anagallis arvensis*	95, 97
-	*Angianthus tomentosus*	97
Yes	*Aotus subspinescens*	97
Yes	*Atriplex turbinata*	95
-	*Austrostipa mollis* (formerly *Stipa mollis*)	95
Yes	*Austrostipa scabra* subsp. *scabra* (formerly *Stipa scabra* subsp. *scabra*)	95, 97
Yes	*Austrostipa tuckeri* (formerly *Stipa tuckeri*)	97
-	*Avena barbata*	95
-	*Bertya* sp.	95
Yes	*Beyeria leschenaultii*	95, 97
-	*Billardiera versicolor*	97
-	*Blennodia canescens*	95, 97
-	*Brachycome ciliaris* var. *lanuginosa*	95, 97
-	*Bulbine alata*	95
Yes	*Calandrinia granulifera*	97
-	*Calandrinia volubilis*	95, 97
-	*Carthamus lanatus*	95
-	*Centipeda thespidioides*	95
-	*Citrullus lanatus*	95
-	*Cressa cretica*	97
Yes	*Cryptandra amara* var. *floribunda*	95, 97
Yes	*Daviesia acicularis*	95, 97
-	*Einadia nutans* subsp. *oxycarpa*	95, 97
-	*Epaltes australis*	95
-	*Eragrostis dielsii*	95
-	*Erodium cygnorum* subsp. *glandulosum*	95, 97
-	*Frankenia serpyllifolia*	95
-	*Gahnia lanigera*	97
-	*Gnaphalium sphaericum*	95, 97
-	*Gnephosis eriocarpa*	95
-	*Goodenia glauca*	97
Yes	*Goodenia havilandii*	95, 97

New SFWP	Botanical name	When Found
Yes	*Gypsophila australis*	97
-	*Halosarcia pergranulata*	97
-	*Halosarcia* sp.	97
Yes	*Lasiopetalum behrii*	97
-	*Lemooria burkittii*	95, 97
-	*Lepidium monoplocoides*	97
-	*Lepidosperma* sp. aff. *viscidum*	97
-	*Limosella curdieana*	97
-	*Lomandra leucocephala* subsp. *leucocephala*	95, 97
-	*Lotus cruentus*	95
-	*Maireana pentagona*	95
-	*Menkea australis*	97
-	*Millotia tenuifolia* var. *tenuifolia*	97
-	*Myoporum platycarpum* subsp. *perbellum*	95
Yes	*Pentaschistis airoides*	97
-	*Plantago turrifera*	95, 97
-	*Poa fax*	95
-	*Pogonolepis muelleriana*	95, 97
-	*Polygonum aviculare*	95
-	*Pterostylis* sp. aff. *biseta*	97
Yes	*Ranunculus trilobus*	95
-	*Rhodanthe microglossa*	95
-	*Rhyncharrhena linearis*	95, 97
-	*Rutidosis helichrysoides*	95
Yes	*Sagina apetala*	97
-	*Scaevola spinescens*	97
-	*Senecio quadridentatus*	97
-	*Sida* sp. aff. *corrugata*	95, 97
Yes	*Silene nocturna*	97
-	*Stuartina hamata*	97
Yes	*Stuartina muelleri*	97
Yes	*Swainsona sericea*	95, 97
-	*Synaptantha tillaeacea*	97
-	*Thysanotus patersonii*	95, 97
-	*Tripogon loliiformis*	97
Yes	*Triptilodiscus pygmaeus*	95, 97
Yes	*Velleia arguta*	97
Yes	*Velleia paradoxa*	97
-	*Vittadinia condyloides*	95, 97
-	*Vittadinia eremaea*	95, 97
Yes	*Vittadinia sulcata*	95, 97

Group 2 Lake beds with *Casuarina pauper*, *Dodonaea viscosa* subsp. *angustissima*, *Alectryon oleifolius* subsp. *canescens*, herbfield, or *Atriplex vesicaria* subsp. *macrocystidea* shrubland; mallees without abundant *Triodia scariosa* and sometimes with *Casuarina pauper.* This group was represented in all survey areas with 13 of 56 transects in 1995 survey and 5 of 22 transects in the northern area, 12 of 30 transects in the central area, but only 2 transects in the southern area and 4 transects outside the southern target area in the 1997 survey.

Group 3 Mallee with abundant *Triodia scariosa.* This group was represented in all survey areas with 21 of 56 transects in the 1995 survey, 9 of 22 transects in the northern area, 15 of 30 transects in the central area, and 16 of 22 transects in the southern target area in the 1997 survey.

The grouping of individual transects is shown in Appendix 1.

Fauna observations

Investigations by Dawson and Ellis (1994) on open plains in far western New South Wales demonstrated that domestic sheep (*Ovis aries*) and red kangaroos (*Macropus rufus*) had considerable dietary overlap (87%) with grasses being the major component for both species. The diet of feral goats (*Capra hircus*) at Fowlers Gap Research Station (approximately 250 km north of the study area) was studied by Dawson and Ellis (1996). Fowlers Gap lies approximately 250 km north of the study site and has a diverse topography, the western portion includes part of the Barrier Ranges, whereas flood plains occur in the east. Goats have a broad diet with a preference for browsing, taxa consumed included *Acacia aneura* (Mulga), *Alectryon oleifolius* (Rosewood), *Canthium oleifolium* (Wild Lemon), *Casuarina pauper* (Belah) and *Myoporum platycarpum* (Sugarwood), eucalypts were not eaten.

Scats were collected at the time of the vegetation survey. At this time, there was standing water in many of the clay former lake beds. Grazing animals, especially kangaroos, were observed near standing water. Kangaroo scats were recorded in all transects where scats had been collected. Goats were the second most widespread of the animal species noted in the area. Goat scats were not recorded in:

- the central area in mallee with *Triodia* (transects 67, 69, 70, 79, 83, 84, 85) and former lake beds (transects 72, 78, 80, 81, 82, 86)
- the southern area in mallee with *Triodia* (transect 115) and former lake bed (transect 130).

Goats were recorded in all transects sampled in the northern area. Sheep were recorded once and possibly twice on four sampled transects in the northern area, four times in 20 sampled transects in the central area, and three times on 22 sampled transects in the southern area. Emus (*Dromaius novaehollandiae*) were recorded infrequently. Emus did not appear to discriminate in terms of vegetation structure and were noted on each of the three major vegetation groups (transects 71, 74, 129).

Rabbits were not recorded in the northern area. They were noted once in the central area (transect 71 in mallee with *Triodia*) and in 7 of the 22 transects in the southern area (five lake bed, and two mallee with *Triodia* transects). The scat collections appear to be consistent with Dawson and Ellis (1996) at Fowlers Gap, namely that kangaroos can travel large distances from watering holes, goats are tolerant of the arid conditions and sheep are restricted. The fencing in the area may have limited the distribution of sheep, but it is more likely that the lack of water determined their distribution. The southern area contained the largest core area of undisturbed vegetation; observations of scat densities during surveys in the southern area indicated a marked decrease in goat presence at distances in excess of 8 km from water sources.

Conclusion

Surveys of the Pooncarie area were conducted in 1995 and 1997. An area centred at 629000N and 680000E was examined during 1995, whereas the 1997 survey targeted three zones that were selected to be more than 5 km from any artificial watering points. The areas surveyed, 100 km^2 (1995) and 468 km^2 (1997) were relatively remote from roads and human habitation. The surveys covered approximately 4% of the 15 180 km^2 mapped by Porteners et al. (1997). Porteners et al. (1997) reported nine species not previously recorded for the South Far Western Plains botanical subdivision of New South Wales, namely, *Abutilon fraseri*, *Amaranthus macrocarpus* var. *macrocarpus*, *Chamaesyce* species B, *Cheilanthes distans*, *Cheilanthes lasiophylla*, *Digitaria ammophila*, *Evolvulus alsinoides* var. *decumbens*, *Leptorhynchus panaetiodes* and *Sporobolus caroli*. None of these species was recorded in our 1995 and 1997 surveys. However, we noted 78 species that had not previously been recorded by Porteners et al. (1997) and/or recorded in the South Far Western Plains botanical division (Harden 1990–1993). There were 136 ephemeral species (95 in 1995 and 112 in 1997) recorded. Of these ephemerals, 30 (22%) were exotics. The timing of the Porteners et al. (1997) survey coincided with a drought, whereas the 1995 and 1997 surveys followed rain which would have encouraged the germination of ephemerals.

Despite the remoteness from artificial watering points, scats of native and exotic grazing animals were found in the 1997 survey areas. Kangaroo scats were recorded at all collection locations and goat scats were frequently observed. Animals were observed near the standing water that collected in the clay former lake beds after rain.

In the 1997 survey, the number of plant species recorded in the 300 km^2 central area (218 total, 199 native, 19 exotic) was similar to the number in the 150 km^2 southern area (233 total, 210 native, 23 exotic). The lower number of species recorded in the 18 km^2 northern area (167 total, 145 native, 22 exotic) is likely to be related to the smaller size of the sampling area (Fig. 2). Exotic plants were part of the flora assemblage in virtually all locations sampled. The presence of exotic seedlings, such as *Hypochoeris glabra*, indicates their very high wind-borne dispersal ability. In many communities, their seeds germinate after rain but the plants fail to establish in the longer term. The numbers of exotic species have been consistent between the 1995 survey (39 exotics) and the 1997 survey (34 exotics), also between the three target areas in 1997 (19–22 exotics). In 1995, 15% of the species noted were exotics. Exotics formed approximately 10% of the total species diversity in the 1997 surveys (13% in northern area, 9% in central and 10% in southern areas).

In terms of conservation significance, nineteen species of National, State and/or Regional level were recorded in the areas surveyed in 1997. Four species of significance were noted in the northern, 11 in the central and 12 in the southern area. In 1995, 12 species of conservation significance (National, State and/or Regional) were recorded. No Endangered Ecological Communities (TSC Act 1995) were noted.

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Appendix 1. Site locations and soil and vegetation descriptions for spots and transects

Soils as described by Green (1980):
Sandplains: Ov — Overnewton, Dunefield: Ap — Arumpo, Mm — Mandleman, Lh — Leaghur
Playas and Basins: Gn — Garnpung, Mu — Mungo
Vegetation as described by Porteners et al. (1997):
3a Irregular Dune Mallee, 3b Linear Dune Mallee, 3d Sandplain Mallee,
4 Belah-Rosewood, 8 Black Bluebush, 22 Disturbed Shrubland Complex, 30 Lunette Shrubland
OA Open Areas, C Cleared and/or cropped

Spots A1–A68: 1995
A69, A79–A81, A85: Northern 1997
A70–A78, A82–A84, A86–A87: Central 1997
A88–A94, A96–A106, A109–A130: Southern 1997

Spot	Spot locations		Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
	North	East					
A1	6294500N	674200E	3a	Ap	19	1	5
A2	6294300N	674300E	3a	Ap	1	0	0
A3	6294300N	674800E	3a	Ap	1	0	0
A4	6294100N	675300E	3a	Ap	1	0	0
A5	6294400N	675400E	3a	Ap	1	0	0
A6	6294300N	675800E	3a	Ap	7	0	0
A7	6294400N	676000E	3a	Ap	8	0	0
A8	6294200N	676250E	3a	Ap	16	0	0
A9	6294000N	676400E	3a	Ap	4	0	0
A10	6293800N	676700E	3a	Ap	5	0	0
A11	6294100N	677200E	3a	Ap	6	1	17
A12	6293800N	677400E	3a	Ap	14	1	7
A13	6293700N	678300E	3a	Ap	22	5	23
A14	6293700N	678700E	3a	Ap	10	1	10
A15	6293600N	679200E	3a	Ap	8	0	0
A16	6293800N	679600E	3a	Ap	1	0	0
A17	6293700N	680000E	3a	Ap	6	1	17

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A18	6293300N	682100E	3a	Lh	9	0	0
A19	6292500N	683100E	3a	Gn	1	0	0
A20	6290600N	682700E	3a	Ap/Lh	12	3	25
A21	6290400N	682600E	3a	Ap/Lh	16	3	19
A22	6291400N	675600E	3a	Ap	3	0	0
A23	6290200N	682400E	3a	Ap	18	6	33
A24	6297800N	672600E	3a	Mm	1	0	0
A25	6297600N	672700E	3a	Mm	26	7	27
A26	6296800N	672400E	3a	Mm	2	0	0
A27	6290800N	673800E	3a	Ap	4	0	0
A28	6291250N	677300E	3a	Ap	22	3	14
A29	6295400N	679300E	3a	Ap	18	1	6
A30	6291000N	681000E	3a	Ap	10	1	10
A31	6290750N	681100E	3a	Ap	17	4	24
A32	6291000N	681500E	3a	Mm	45	16	36
A33	6290500N	681350E	3a	Ap	14	2	14
A34	6290000N	681900E	3a	Ap	16	6	38
A35	6289200N	681100E	3a	Ap	4	0	0
A36	6291100N	679200E	3a	Ap	1	0	0
A37	6274700N	666100E	3a	Mm	7	2	29
A38	6290800N	679500E	3a	Ap	9	1	11
A39	6290350N	679200E	3a	Ap	1	0	0
A40	6290350N	679000E	3a	Ap	23	6	26
A41	6290500N	677600E	3a	Ap	16	2	13
A42	6289800N	678400E	3a	Ap	11	0	0
A43	6289600N	678000E	3a	Ap	16	0	0
A44	6289400N	677800E	3a	Ap	7	0	0
A45	6289750N	678200E	3a	Ap	19	5	26

Spot	Spot locations North	 East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A46	6291500N	679500E	3a	Ap	25	4	16
A47	6294000N	684250E	3a	Gn	15	5	33
A48	6274200N	666200E	3a	Mm	17	7	41
A49	6274000N	666000E	3a	Mm	18	5	28
A50	6290000N	675400E	3a	Ap	17	1	6
A51	6289400N	677200E	3a	Ap	19	1	5
A52	6289250N	677500E	3a	Ap	17	4	24
A53	6291000N	675200E	3a	Ap	20	4	20
A54	6292400N	676500E	3a	Ap	8	0	0
A55	6292750N	677900E	3a	Ap	8	4	50
A56	6291600N	678200E	3a	Ap	15	0	0
A57	6291600N	678800E	3a	Ap	5	0	0
A58	6292500N	674750E	3a	Ap	17	5	29
A59	6301000N	696600E	C	Gn	23	8	35
A60	6306300N	695400E	OA/22	Gn	10	6	60
A61	6280900N	671100E	3b	Mm	9	0	0
A62	6280000N	671000E	3b	Mm	37	1	3
A63	6278900N	670800E	3a	Mm	13	2	15
A64	6276800N	670500E	3a	Ap/Mm	24	2	8
A65	6276400N	670400E	3a	Ap/Mm	23	4	17
A66	6274200N	670100E	3a	Ap	23	5	22
A67	6271250N	664100E	3a	Mm	2	0	0
A68	6282000N	671400E	3b	Ap/Mm	32	2	6
A69	6314000N	687000E	3a	Mm	1	0	0
A70	6281000N	659000E	3a	Mm	9	0	0
A71	6281700N	660500E	3a	Mm	0	0	0
A72	6290750N	674700E	3a	Ap	4	0	0
A73	6281700N	660100E	3a	Mm	4	0	0

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A74	6281500N	659700E	3a	Mm	6	0	0
A75	6290700N	679800E	3a	Ap	32	6	19
A76	6290700N	682700E	3a	Lh	5	0	0
A77	6284100N	672500E	3b	Ap	4	0	0
A78	6279400N	656250E	3a	Mm	5	1	20
A79	6312350N	687100E	3a	Ov	11	1	9
A80	6311700N	689100E	3a/3b/3c	Gn	3	0	0
A81	6310500N	688100E	3a	Gn	21	2	10
A82	6282700N	656900E	3a	Mm	18	4	22
A83	6275100N	659400E	3a	Mm	20	0	0
A84	6277500N	661900E	3a	Mm	4	0	0
A85	6305700N	687250E	4/30	Gn	8	0	0
A86	6279600N	654000E	3a	Mm	7	3	43
A87	6278600N	655800E	3a	Mm	27	3	11
A88	6266100N	660600E	4	Mm	2	0	0
A89	6264500N	657100E	3a	Mm	1	0	0
A90	6264000N	658000E	3a	Mm	1	0	0
A91	6260900N	658400E	3a	Mm	1	0	0
A92	6257100N	660400E	3a	Mm	1	0	0
A93	6262300N	649200E	3a	Mm	1	0	0
A94	6260750N	670000E	3a	Mm	1	0	0
A95	non existent						
A96	6262700N	649200E	3a	Mm	1	0	0
A97	6266600N	647400E	3a	Mm	1	0	0
A98	6263500N	658500E	3a	Mm	1	0	0
A99	6270600N	661250E	3a	Mm	1	0	0
A100	6260800N	658000E	3a	Mm	1	0	0
A101	6262600N	649100E	3a	Mm	1	0	0

Spot	Spot locations North	East	Vegetation	Soil	Total no.of species	Exotic species	Percent exotic species
A102	6269600N	670400E	3a	Ap	3	1	33
A103	6269600N	671800E	3a	Ap	47	7	7
A104	6262800N	658200E	3a	Mm	1	0	0
A105	6269200N	672600E	3a	Mu	33	6	18
A106	6272800N	670600E	3a	Ap	1	0	0
A107	non existent						
A108	non existent						
A109	6267400N	649500E	3a	Mm	9	0	0
A110	6262900N	661600E	3a	Mm	21	5	24
A111	6261600N	662000E	3a	Mm	7	0	0
A112	6261200N	661000E	3a	Mm	11	2	18
A113	6259500N	658100E	3a	Mm	5	0	0
A114	6260100N	658100E	3a	Mm	15	1	7
A115	6260100N	658500E	3a	Mm	14	2	14
A116	6261700N	658650E	3a	Mm	11	0	0
A117	6262800N	658850E	3a	Mm	7	0	0
A118	6262600N	669600E	3a	Mm	10	1	10
A119	6263700N	669800E	3a	Mm	4	0	0
A120	6264400N	670000E	3a	Mm	10	0	0
A121	6265100N	670000E	3a	Mm	6	0	0
A122	6261500N	648900E	3b	Mm	9	0	0
A123	6264200N	649100E	3a	Mm	2	0	0
A124	6265600N	649300E	3a	Mm	5	1	20
A125	6266800N	651500E	3a	Mm	9	0	0
A126	6266500N	652500E	3a	Mm	3	0	0
A127	6266100N	652100E	3a	Mm	1	0	0
A128	6269500N	672400E	8/22	Mu	2	0	0
A129	6269200N	671800E	8/22	Mu	9	17	11
A130	6271400N	671300E	8/22	Mu	7	0	0

Transects 1–56: 1995

57–66, 97–108: Northern 1997
67–96: Central 1997
109–130: Southern 1997
Site key: A.l. = *Acacia ligulata*, A.o. = *Alectryon oleifolius* subsp. *canescens*, B.o. = *Beyeria bursariifolia*, Ca.p. = *Callitris preissii*, C.p. = *Casuarina pauper*, D.b. = *Dodonaea bursariifolia*, D.h. = *Duboisia hopwoodii*, D.v. = *Dodonaea viscosa*, G.p. = *Grevillea pterosperma*, L.c. = *Leptospermum coriaceum*, T.s. = *Triodia scariosa*.
(X) = number of quadrats out of a total of 10, in which *Triodia scariosa* was found.

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
1	6296200N	664900E	3a	Ov	Mallee, no T.s.	1	57	9	16
2	6295000N	667400E	3a	Mm	Mallee, T.s. (6)	3	49	5	10
3	6294000N	669200E	3a	Mm	Open C.p., no T.s.	3	53	7	13
4	6292100N	678600E	3a	Ap	Mallee, Ca.p., T.s. (7)	1	50	6	12
5	6291700N	678600E	3a	Ap	Mallee, T.s. (10)	2	28	1	4
6	6291900N	678400E	3a	Ap	Mallee dune crest, T.s. (7)	1	46	4	9
7	6291400N	678000E	3a	Ap	Dense mallee, T.s. (10)	2	39	2	5
8	6292800N	677300E	3a	Ap	Mallee, Ca.p.,T.s (10)	2	28	0	0
9	6291600N	676400E	3a	Ap	Lake Shore, D.h., no T.s.	1	40	10	25
10	6290800N	674200E	3a	Mm	Mallee, T.s. (2)	3	57	5	9
11	6290700N	674800E	3a	Mm/Ap	Lake bed, no T.s.	3	46	10	22
12	6290300N	674700E	4	Mm/Ap	Mallee, T.s. (9)	1	40	1	3
13	6291300N	675600E	3a	Ap	Mallee, T.s. (8)	1	49	6	12
14	6291200N	675900E	3a	Ap	Mallee on dune crest, T.s. (10)	1	53	4	8
15	6290200N	676750E	4	Mm/Ap	Mallee on dune crest, T.s. (10)	2	35	1	3
16	6291600N	676750E	3a	Ap	Mallee, Ca.p., T.s. (9)	2	24	3	13

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
17	6291100N	677600E	3a	Ap	Mallee, T.s. (9)	2	28	1	4
18	6291250N	678200E	3a	Ap	Mallee, G.p., T.s. (10)	2	24	0	0
19	6290700N	679100E	3a	Ap	Lake edge mallee, D.h., T.s. (9)	2	31	3	10
20	6291000N	680000E	3a	Ap	Lake bed, no T.s.	3	33	9	27
21	6290750N	680000E	3a	Ap	Sparse mallee, T.s. (9)	1	57	10	18
22	6294500N	673800E	OA/4sc	Mm	Sandy low mallee, T.s. (10)	2	28	1	4
23	6294400N	675700E	3a	Mm	Mallee on red sand, no T.s.	1	52	4	8
24	6294000N	675600E	3a	Mm	Low mallee, T.s. (8)	2	29	1	3
25	6293800N	677000E	3a	Mm	Mallee on red sand, T.s. (10)	2	36	1	3
26	6293300N	679900E	3a	Ap	Mallee, T.s. (9)	2	31	2	6
27	6293300N	680700E	3a	Ap	Dune crest mallee, red sand, T.s. (10)	1	45	3	7
28	6293300N	681400E	3a	Mm	Dune crest mallee, red sand, T.s. (10)	1	45	4	9
29	6293200N	682900E	3a	Mm	Dune crest mallee, red sand, T.s. (8)	1	51	5	10
30	6292900N	683000E	3a	Mm	Dune crest mallee, red sand, T.s. (3)	1	49	7	14
31	6291200N	682800E	3a	Lh	Mature mallee, T.s. (9)	2	26	3	12
32	6289200N	680800E	3b	Ap	Mallee, red sand, T.s. (3)	1	52	11	21
33	6289100N	681500E	3b	Ap	Mallee, Ca.p., T.s. (5)	1	47	8	17
34	6292400N	677600E	3a	Ap	Mallee, Ca.p., T.s. (10)	2	21	3	14
35	6309200N	696700E	4/30	Gn	D.v., no T.s. (mapped as Hopwood community by Porteners et al. 1997)	3	45	9	20
36	6290400N	679300E	3a	Ap	Mallee, G.p., T.s. (10)	1	47	8	17
37	6290300N	678750E	3a	Ap	Mallee, lichens, T.s. (9)	2	29	1	3
38	6289900N	678100E	3b	Ap	Dune crest mallee, surface clay/loam, T.s. (8)	3	32	1	3

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
39	6290200N	677800E	3b	Ap	Mallee on rocky outcrop, C.p., T.s. (2)	3	44	6	14
40	6290300N	678300E	3a	Ap	Depression, Ca.p., T.s. (9)	1	38	8	21
41	6291250N	679600E	3a	Ap	Mallee, T.s. (9)	2	24	6	25
42	6291400N	679800E	3a	Ap	Depression, D.h., T.s. (7)	1	28	6	21
43	6291750N	679300E	3a	Ap	Lake bed, no T.s.	3	36	7	19
44	6291900N	679100E	3a	Ap	Mallee, no T.s.	1	39	7	18
45	6297200N	679500E	3a	Mm	C.p. woodland, no T.s.	3	28	2	7
46	6289100N	676900E	3b	Ap	Mallee, open sand, T.s. (4)	1	36	3	8
47	6289000N	677500E	3b	Ap	Mallee on clay depression, C.p., no T.s.	3	46	2	4
48	6290100N	675250E	3b	Ap	Mallee, Ca.p., T.s. (4)	2	43	4	9
49	6291400N	674750E	3a	Mm	Mallee, T.s. (10)	1	36	3	8
50	6293200N	677600E	3a	Ap	D.v., no T.s.	3	41	7	17
51	6293300N	678000E	3a	Ap	Mallee, Ca.p., T.s. (2)	2	25	3	12
52	6283600N	671600E	3b	Ap	Dune crest mallee, T.s. (10)	2	28	2	7
53	6282600N	671400E	3b	Ap	Dune crest mallee, T.s. (7)	2	47	3	6
54	6281200N	671100E	3a	Mm/Ap	Mallee, T.s. (10)	2	37	4	11
55	6275600N	670400E	3a	Ap	Lake bed, A.o., T.s. (4)	3	34	6	18
56	6275000N	666400E	3a	Mm	Mallee, T.s. (10)	1	31	3	10
57	6314100N	687900E	3b	Mm	Lake bed, C.p., no T.s.	3	31	2	6
58	6312800N	688800E	3a	Mm	Dune crest, sandy, mallee, no T.s.	1	49	5	10
59	6312200N	688200E	3a	Mm	Mallee, T.s. (10)	2	28	2	7
60	6311800N	688000E	3a	Mm	Dune crest, sandy, L.c., T.s. (10)	1	19	1	5
61	6311900N	686800E	3a	Mm	Mallee, T.s. (10)	2	29	1	3

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
62	6312000N	685300E	3a	Mm	Mallee, T.s. (10)	2	13	0	0
63	6311200N	685100E	3a	Mm	Mallee, no T.s.	3	50	8	16
64	6310000N	688200E	3a	Mm	Dune crest, L.c., T.s. (3)	1	32	2	6
65	6309750N	688200E	3a	Mm	Lake bed, no T.s.	3	26	5	19
66	6308400N	687400E	3a	Mm	Mallee, T.s. (9)	1	52	6	12
67	6280600N	659700E	3a	Mm	Mallee, T.s. (10)	2	22	0	0
68	6280500N	660600E	3a	Mm	Mallee, L..c., T.s. (10)	2	23	1	4
69	6281400N	660600E	3a	Mm	Mallee, T.s. (10)	2	19	0	0
70	6282700N	660100E	3a	Mm	Mallee, T.s. (10)	2	20	1	5
71	6283400N	660000E	3a	Mm	Dune crest, A.l., T.s. (5)	2	33	4	12
72	6288500N	668400E	4	Mm	Lake bed, C.p., no T.s.	3	43	2	5
73	6288000N	668550E	3b	Mm	Lake bed, no T.s.	3	34	0	0
74	6287600N	668600E	3b	Mm	Mallee, T.s. (4)	1	55	6	11
75	6286400N	669200E	3b	Mm	Mallee, T.s. (10)	2	34	0	0
76	6284700N	668900E	3b	Mm	Mallee, T.s. (8)	1	43	1	2
77	6284500N	670600E	3b	Mm	Lake bed, C.p., no T.s.	3	29	0	0
78	6290700N	674800E	3a	Mm	Lake bed, no T.s.	3	40	5	13
79	6291250N	678200E	3a	Ap	Mallee on gravel slope, T.s. (10)	2	19	0	0
80	6287800N	673000E	4	Mm	C.p., no T.s.	3	30	0	0
81	6286700N	671800E	3b	Mm	D.v., no T.s.	3	33	3	9
82	6284750N	671500E	3b	Mm	Lake bed, A.o. with mallee, no T.s.	3	40	3	8
83	6283500N	670500E	3b	Ap	Mallee near dune crest, T.s. (9)	2	34	2	6
84	6280400N	671750E	3a	Mm	Mallee, T.s. (9)	2	29	0	0

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
85	6280100N	671500E	3a	Mm	Dune crest, A.. l., T.s. (10)	2	26	1	4
86	6281700N	671000E	3b	Ap	Lake bed, C.p., A.o., no T.s.	3	57	5	9
87	6281400N	670000E	3a	Ap	Ridgetop with mallee, T.s. (10)	2	33	2	6
88	6280900N	667900E	3a	Mm	Sparse mallee, A.l., T.s. (5)	2	34	1	3
89	6281200N	665750E	3a	Mm	Lake bed, no T.s.	3	47	5	9
90	6279900N	664200E	3a	Mm	Sparse mallee, T.s. (4)	2	33	2	6
91	6277900N	661900E	3a	Mm	Lake bed, no T.s.	3	47	4	9
92	6276800N	658500E	3a	Mm	Lake bed, C.p., no T.s.	3	37	1	3
93	6277850N	657600E	3a	Mm	Lake bed, C.p., no T.s.	3	20	1	5
94	6278700N	656100E	3a	Mm	Open sand plain, T.s. (1)	1	38	5	13
95	6279700N	653000E	3a	Mm	Mallee with B.o., T.s. (5)	2	30	0	0
96	6278400N	656700E	3a	Mm	Mallee on gravel slope, T.s. (6)	2	25	0	0
97	6311000N	689900E	3a	Mm	Sand dune mallee, T.s. (4)	1	50	5	10
98	6310700N	689200E	3a	Mm	Low sand ridge, open mallee woodland, no T.s.	1	34	4	12
99	6310400N	688900E	3a	Mm	Ridgetop woodland, A.o., no T.s.	1	48	13	27
100	6309900N	687400E	3a	Mm	Lake bed, C.p., A.o., no T.s.	3	38	6	16
101	6308700N	686000E	3a	Mm	Mallee, T.s. (10)	2	29	3	10
102	6307400N	685900E	3a	Mm	Mallee, T.s. (8)	2	28	0	0
103	6306500N	685800E	3a	Mm	Mallee, T.s. (8)	2	23	1	4
104	6305800N	687100E	3a	Mm	Lake bed, C.p., A.o., no T.s.	3	54	6	11
105	6306700N	687200E	3a	Mm	Mallee, T.s. (10)	2	25	2	8
106	6307700N	686900E	3a	Mm	Mallee, T.s. (8)	2	30	1	3
107	6308200N	687200E	3a	Mm	Dune ridge, A.o., no T.s.	1	46	10	22

Transects

T	North	East	Vegetation	Soil	Site	Ordination group	Total no. of species	Exotic species	% exotic species
108	6308900N	687800E	3a	Mm	Mallee, T.s. (10)	2	29	3	10
109	6267400N	649500E	3a	Mm	D.v., no T.s.	3	33	5	15
110	6262900N	661600E	3a	Mm	Mallee on dune crest, T.s. (8)	2	46	6	13
111	6261600N	662000E	3a	Mm	Mallee on dune crest, T.s. (2)	2	43	2	5
112	6261200N	661000E	3a	Mm	Swale of parabolic dune, no T.s.	3	23	3	13
113	6259500N	658100E	3a	Mm	Mallee on dune crest, T.s. (9)	2	44	1	2
114	6260100N	658100E	3a	Mm	Mallee on red swale, D.b., T.s. (2)	2	30	0	0
115	6260100N	658500E	3a	Mm	Sand plain mallee, T.s. (10)	2	40	2	5
116	6261700N	658650E	3a	Mm	Sand plain mallee, T.s. (10)	2	30	0	0
117	6262800N	658850E	3a	Mm	Sand plain mallee, T.s. (8)	2	25	0	0
118	6262600N	669600E	3a	Mm	Sand plain mallee, T.s. (7)	2	40	0	0
119	6263700N	669800E	3a	Mm	Mallee on red swale, T.s. (10)	2	26	0	0
120	6264400N	670000E	3a	Mm	Dune crest mallee, T.s. (10)	2	27	0	0
121	6265100N	670000E	3a	Mm	Sand plain mallee, T.s. (9)	2	18	1	6
122	6261500N	648900E	3b	Mm	Red swale, T.s. (3)	2	32	0	0
123	6264200N	649100E	3a	Mm	Sand plain mallee, T.s. (10)	2	26	0	0
124	6265600N	649300E	3a	Mm	Dune crest mallee, T.s. (8)	2	31	0	0
125	6266800N	651500E	3a	Mm	Mallee on red swale, no T.s.	3	45	5	11
126	6266500N	652500E	3a	Mm	Dune crest mallee, T.s. (10)	2	13	0	0
127	6266100N	652100E	3a	Mm	Sand plain mallee, T.s. (9)	2	25	0	0
128	6269500N	672400E	8/22	Mu	Lake bed, no T.s.	3	58	11	19
129	6269200N	671800E	8/22	Mu	Lake bed, no T.s.	3	32	6	19
130	6271400N	671300E	8/22	Mu	Lake bed, no T.s.	3	39	9	23

Appendix 2. Ephemeral Species

Key :
* : exotic species
95: 1995 survey
97e: entire 1997 survey
N: northern area, 1997
C: central area, 1997
S: southern area, 1997

Species	**95**	**97e**	**N**	**C**	**S**
Dicotyledons					
Aizoaceae					
Tetragonia moorei sp. nov.	x	x	x	x	x
Apiaceae					
Daucus glochidiatus	x	x	x	x	x
Trachymene cyanopetala	x	x		x	x
Trachymene sp. (unidentified)		x		x	
Asteraceae					
Actinobole uliginosum	x	x	x	x	x
Angianthus brachypappus		x			x
Angianthus tomentosus		x			x
Brachycome leptocarpa	x				
Brachycome lineariloba	x	x	x	x	x
Bracteantha bracteata	x				
Calotis cymbacantha	x				
Calotis hispidula	x	x	x	x	x
**Carthamus lanatus*	x				
**Centaurea melitensis*	x	x	x		
Centipeda thespidioides	x				
Ceratogyne obionoides		x		x	x
Chthonocephalus pseudevax		x	x	x	x
Epaltes australis	x				
Gnaphalium sphaericum	x	x		x	
Gnephosis eriocarpa	x				
Gnephosis tenuissima	x	x	x	x	x
Hyalosperma semisterile		x			x
**Hypochoeris glabra*	x	x	x	x	x
Isoetopsis graminifolia	x	x	x	x	x
Lemooria burkittii	x	x	x	x	x
Millotia macrocarpa	x	x	x	x	x
Millotia perpusilla		x		x	x
Millotia tenuifolia var. *tenuifolia*		x			x
Myriocephalus pluriflorus		x		x	
Myriocephalus stuartii	x	x	x	x	x
Podolepis capillaris	x	x	x	x	x
Podolepis sp. (unidentified)		x		x	
Podotheca angustifolia	x	x		x	x
Pogonolepis muelleriana	x	x		x	x
Pseudognaphalium luteoalbum	x				
Rhodanthe corymbiflora		x			x
Rhodanthe floribunda	x	x	x		
Rhodanthe microglossa	x				
Rhodanthe moschata	x	x	x	x	x
Rhodanthe pygmaea		x	x	x	x
Rhodanthe sp.		x			x
Rhodanthe stuartiana		x	x	x	x
Rhodanthe uniflora	x	x			x
Senecio glossanthus	x	x	x	x	x
Senecio gregorii	x				
**Sonchus asper*		x	x		
**Sonchus oleraceus*	x	x	x		x
Stuartina hamata		x		x	

Species	95	97e	N	C	S
Asteraceae cont.					
Stuartina muelleri		x			x
Triptilodiscus pygmaeus	x	x		x	x
Vittadinia cervicularis subsp. *cervicularis*		x	x		x
Vittadinia cuneata var. *morrisii*	x	x	x	x	
Vittadinia dissecta var. *hirta*	x	x	x	x	x
Vittadinia eremaea	x	x	x	x	x
Vittadinia pterochaeta	x	x		x	
Vittadinia sp.	x	x	x	x	x
Vittadinia sulcata	x	x	x	x	
Waitzia acuminata	x	x	x	x	x
Boraginaceae					
**Echium plantagineum*	x				
Omphalolappula concava	x	x	x	x	x
Plagiobothrys plurisepaleus		x	x	x	x
Brassicaceae					
**Alyssum linifolium*	x	x	x	x	x
Blennodia canescens	x	x	x	x	
**Brassica tournefortii*	x	x	x	x	x
**Carrichtera annua*		x	x		
Geococcus pusillus		x			x
Harmsiodoxa brevipes var. *brevipes*	x	x	x	x	x
Lepidium fasciculatum	x				
Lepidium monoplocoides		x		x	
Lepidium papillosum	x	x	x	x	x
Lepidium phlebopetalum	x	x	x	x	x
**Lepidium* sp.		x	x	x	x
Menkea australis		x	x	x	x
Sisymbrium erysimoides		x		x	x
Stenopetalum lineare	x	x	x	x	x
Stenopetalum sphaerocarpum		x		x	x
Campanulaceae					
Wahlenbergia gracilenta	x	x	x	x	x
Wahlenbergia tumidifructa	x	x	x	x	
Caryophyllaceae					
Gypsophila australis		x	x		
**Herniaria hirsuta*	x	x	x	x	
**Sagina apetala*		x		x	
Scleranthus minusculus	x	x	x	x	x
**Silene apetala*	x	x	x	x	x
**Silene nocturna*		x			x
Chenopodiaceae					
Chenopodium cristatum	x	x		x	x
Chenopodium desertorum subsp. *desertorum*			x	x	x
Chenopodium desertorum subsp. indet.	x				
Chenopodium desertorum subsp. *rectum*	x		x	x	x
Chenopodium melanocarpum	x	x	x	x	x
Crassulaceae					
Crassula colorata var. *acuminata*	x	x	x	x	x
Euphorbiaceae					
Poranthera microphylla	x	x		x	
Fabaceae Faboideae					
**Medicago laciniata*		x	x		
**Medicago minima*	x	x	x	x	x
Geraniaceae					
**Erodium cicutarium*	x	x	x	x	x
Erodium crinitum	x	x	x	x	x
Erodium cygnorum subsp. *glandulosum*	x	x	x	x	
Erodium sp.		x	x	x	

Species	95	97e	N	C	S
Goodeniaceae					
Goodenia havilandii	x	x	x	x	x
Goodenia pusilliflora	x	x	x	x	x
Malvaceae					
**Malva parviflora*	x				
Plantaginaceae					
Plantago cunninghamii	x				
Plantago drummondii	x	x		x	x
Plantago sp.		x	x		x
Plantago turrifera	x	x	x	x	x
Portulacaceae					
Calandrinia eremaea	x	x	x	x	x
Calandrinia granulifera		x		x	x
Ranunculaceae					
Myosurus minimus var. *australis*	x				
Ranunculus pentandrus var. *platycarpus*		x			x
**Ranunculus trilobus*	x				
Rubiaceae					
Synaptantha tillaeacea		x		x	
Solanaceae					
Nicotiana occidentalis subsp. *obliqua*	x		x	x	x
Thymelaeaceae					
Pimelea trichostachya	x	x	x	x	x
Urticaceae					
Parietaria debilis		x	x	x	x
Zygophyllaceae					
Zygophyllum ammophilum	x	x	x	x	x
Zygophyllum apiculatum	x	x	x	x	x
Zygophyllum aurantiacum	x				
Zygophyllum iodocarpum	x	x	x	x	
Zygophyllum ovatum	x	x	x	x	
Zygophyllum simile	x	x	x	x	x
Monocotyledons					
Asphodelaceae					
Bulbine semibarbata	x	x	x	x	x
Juncaginaceae					
Triglochin calcitrapum		x	x	x	x
Poaceae					
Agrostis avenacea	x				
**Aira caryophyllea*	x	x	x	x	
Bromus arenarius	x	x	x	x	x
**Bromus rubens*	x	x	x	x	x
**Bromus* sp.	x				
**Hordeum leporinum*.	x	x	x		
**Hordeum marinum*		x			x
Pentaschistis airoides		x	x	x	x
Poa fax	x				
**Rostraria pumila*	x	x	x	x	x
**Schismus barbatus*	x	x	x	x	x
**Vulpia bromoides*	x	x			x
**Vulpia muralis*	x	x		x	
**Vulpia myuros*	x	x	x	x	x
**Vulpia* sp.		x		x	x

Vegetation and flora of Booti Booti National Park and Yahoo Nature Reserve, lower North Coast of New South Wales.

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Griffith, S.J.[1], Wilson, R.[2] and Maryott-Brown, K.[3] ([1]Division of Botany, School of Rural Science and Natural Resources, University of New England, Armidale NSW 2351; [2]16 Bourne Gardens, Bourne Street, Cook ACT 2614; [3]Paynes Lane, Upper Lansdowne NSW 2430) 2000. Vegetation and flora of Booti Booti National Park and Yahoo Nature Reserve, lower North Coast of New South Wales. Cunninghamia *6(3): 645–715.* The vegetation of Booti Booti National Park and Yahoo Nature Reserve on the lower North Coast of New South Wales has been classified and mapped from aerial photography at a scale of 1: 25 000. The plant communities so identified are described in terms of their composition and distribution within Booti Booti NP and Yahoo NR. The plant communities are also discussed in terms of their distribution elsewhere in south-eastern Australia, with particular emphasis given to the NSW North Coast where compatible vegetation mapping has been undertaken in many additional areas. Floristic relationships are also examined by numerical analysis of full-floristics and foliage cover data for 48 sites. A comprehensive list of vascular plant taxa is presented, and significant taxa are discussed. Management issues relating to the vegetation of the reserves are outlined.

Introduction

The study area

Booti Booti National Park (1586 ha) and Yahoo Nature Reserve (48 ha) are situated on the lower North Coast of New South Wales (32°15'S 152°32'E), immediately south of Forster in the Great Lakes local government area (Fig. 1). The reserves fall within the NSW North Coast biogeographic region of Thackway and Cresswell (1995), and the North Coast botanical subdivision of Anderson (1961).

The larger part of Booti Booti NP consists of Quaternary barrier deposits between the Pacific Ocean and Wallis Lake connecting three headland hill complexes. Several small islands in Wallis Lake are also included in Booti Booti NP — Booti Island, Shepherd Island, Coomba Island, Earps Island, Snake Island, Little Snake Island, Black Rocks and Pelican Island. Yahoo NR is a larger island, also in Wallis Lake.

The present paper is based on a vegetation survey which was undertaken by the authors for the NSW National Parks and Wildlife Service, Hunter District (Griffith et al. 1999).

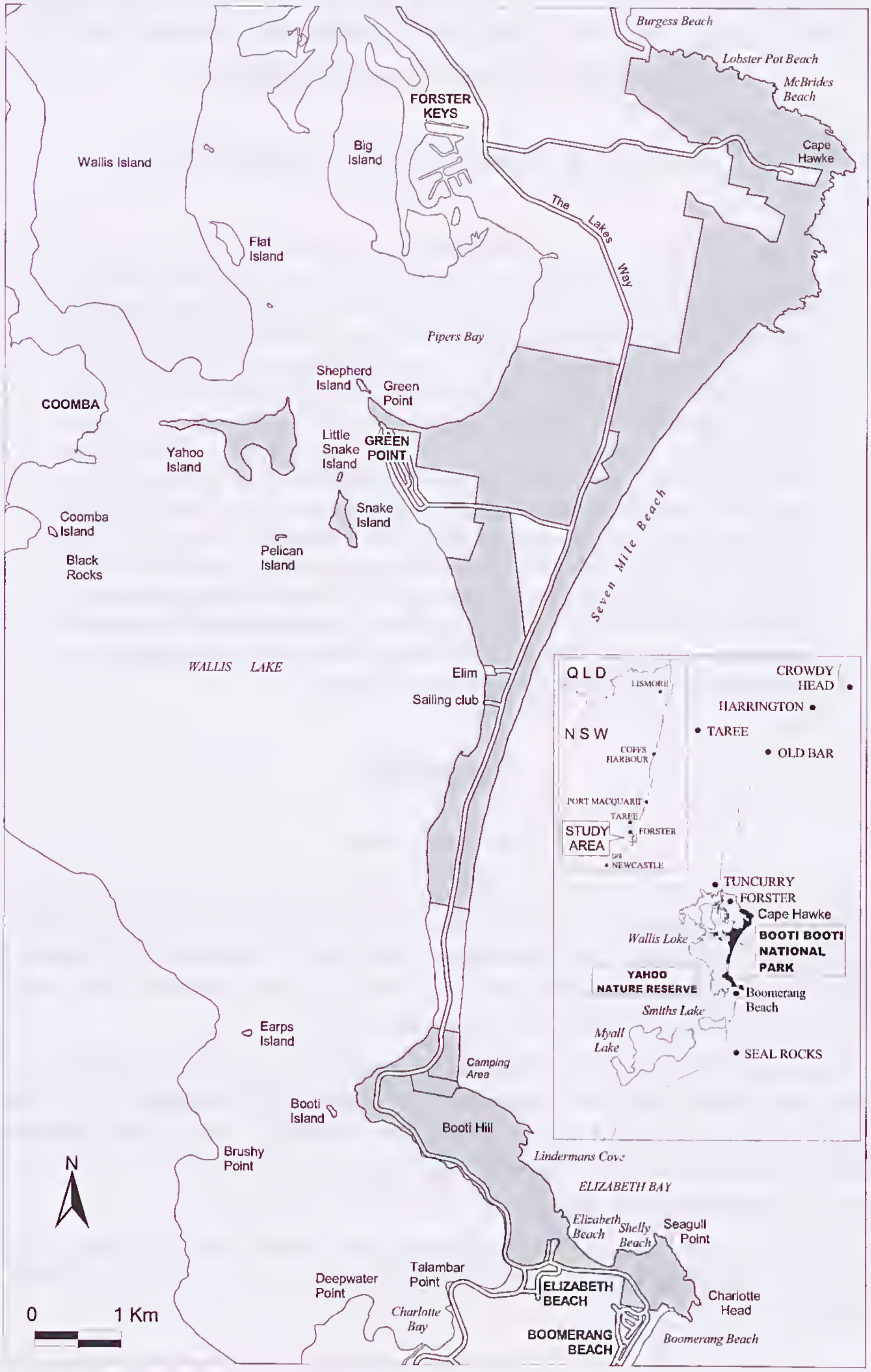

Fig. 1. The location of Booti Booti National Park and Yahoo Nature Reserve (shaded) on the lower North Coast of New South Wales.

Climate

The lower North Coast of NSW experiences a humid subtropical climate (Koeppen typology) which is characterised by mild winters, long hot summers, and precipitation in all seasons. The dominant winter air mass is the polar maritime, and this influences weather patterns for a minimum of 3–6 months (after Oliver 1973, in Linacre and Hobbs 1977). At this time of the year strong, cold winds originate in the south or west. Tropical maritime air dominates in summer for a minimum of three months, and during this time winds often originate in the north or north-east.

The mean annual rainfall for Taree (36 km NNW of Booti Booti NP) is 1178 mm, and an average of 35% of this total falls during the three wettest months of January, February and March. The three driest months of July, August and September receive an average of 17% of the mean annual total. However, annual and seasonal rainfall patterns can vary considerably from year to year, and so result in periods of drought or flood. To illustrate this point, 110 years of record for Harrington (40 km N of Booti Booti NP) yield a variability index for total annual rainfall of 70% (variability index = (90% percentile - 10% percentile)/50% percentile). Similarly, the variability index for monthly rainfall in March (the wettest month on average) is 175%. For monthly rainfall in September (the driest month on average), the variability index is 294% (Bureau of Meteorology 1988; Bureau of Meteorology pers. comm. 1998).

Mean daily maximum temperatures for Taree vary from 28.3 to 28.9°C in the summer months, and from 18.6 to 20.1°C in the winter months. Likewise, mean daily minimum temperatures vary from 16.4 to 18.1°C in summer, and from 5.3 to 7.2°C in winter (Bureau of Meteorology 1988). Frosts are rare in the vicinity of Booti Booti NP and Yahoo NR.

Landforms, geology and soils

Booti Booti NP contains three large hill complexes (landform terms generally follow Speight 1984), and these are dominated by Cape Hawke, Booti Hill and Charlotte Head respectively (Fig. 1). The Cape Hawke complex and the Charlotte Head complex are both composed of sandstone and conglomerate strata of the Conger Formation from the Carboniferous Period. The Booti Hill complex is part of the Wooton Beds, which are also Carboniferous and comprise sandstone, siltstone, claystone, shale, limestone and lavas (NSW Department of Mines 1966). All three hill complexes are interconnected with Quaternary deposits of marine-aeolian and estuarine origin. The Cape Hawke and Charlotte Head complexes were at one time offshore islands, whereas the Booti Hill complex has always been a headland promontory of the mainland (Melville 1984).

The largest hill complex is dominated by Cape Hawke (224 m high). Apart from small beaches such as McBrides and Lobster Pot, the northern and eastern margins of the Cape Hawke complex end in cliffs and rocky outcrops along the ocean. At the south-western extremities, the complex is mantled to an elevation of approximately 50 m with quartzose sands of considerable age (> 140 000 years BP), although these sands have since eroded along gullies (de Castro Lopo 1981, Roy 1982).

During the late Pleistocene the Cape Hawke hill complex was an offshore island some 10 km out to sea and 12 km^2 in area. Refracted waves subsequently formed a tombolo-like lagoon barrier by joining the Cape Hawke complex (and the smaller island of Green Point) to the protruding headland of Booti Hill (Melville 1984). The former island of Charlotte Head also joined with the mainland in the late Pleistocene as a result of deposition. The main phase of Pleistocene barrier sedimentation commenced approximately 140 000 years BP, and this time corresponds with the Last Interglacial Marine Transgression when sea levels were higher (Roy 1982).

The present-day lagoon barrier which extends south from the Cape Hawke hill complex to the Booti Hill complex is approximately 10 km in length, and varies in width from 400 m to 3.25 km. This lagoon barrier separates Wallis Lake from the Pacific Ocean. The seaward sequence of the lagoon barrier consists of Holocene marine-aeolian deposits which overly or interface with low-lying and partly eroded Pleistocene sands, some of which are humate-cemented. In Wallis Lake, Pleistocene sands extend to a depth of 25 m below the present sea level. The western (lake) side of the lagoon barrier consists of sediments of estuarine origin. These sediments are sandy backbarrier deposits of Pleistocene age, Holocene backbarrier washover and tidal delta sands, and Holocene basin mud and intertidal deposits. Estuarine clays and clayey sands underlie all of the abovementioned sediments, and these estuarine deposits in turn rest on bedrock (Melville 1984, Roy 1982). Much of the present lagoon barrier is less than 10 m in elevation, although sand dunes reach a height of 20–30 m at a few locations. The landform pattern of the lagoon barrier is rolling to level.

The Booti Hill hill complex extends about 3 km in a north-west to south-east direction, and varies in width from 600 m to 1 km. The highest point in this complex is Booti Hill itself (169 m). Hillslopes on the south-western side of the complex form the shore of Wallis Lake, while the north-eastern and eastern slopes often terminate in sea cliffs. Elizabeth Beach occupies a protected situation between the Booti Hill complex and the Charlotte Head complex. Elizabeth Beach consists of Holocene marine-aeolian sands which onlap sandy backbarrier deposits of Pleistocene age and estuarine origin (Roy 1982).

Of the three hill complexes in Booti Booti NP, the one dominated by Charlotte Head is the smallest and lowest (96 m). The Charlotte Head complex terminates in extensive sea cliffs to the east and north-east, and the southern part of the complex is mantled with aeolian sand. To the north-west the complex has an open depression which drains towards Shelly Beach.

Some of the islands in Wallis Lake are composed entirely or partly of bedrock, whereas other islands consist of Quaternary sediments only. Shepherd and Yahoo Islands contain a bedrock knoll (identified as toscanite for Yahoo Island in Floyd 1990) against which estuarine sediments have accumulated. On the other hand, Black Rocks, Booti Island, Earps Island and Coomba Island are entirely bedrock. Snake and Little Snake Islands consist of well vegetated tidal and supratidal sediments, whereas Pelican Island is a sandy tidal flat which is predominantly unvegetated.

The Soil Conservation Service of NSW (1985) has identified several soil groups for the bedrock hill complexes in Booti Booti NP. These groups are red and yellow podzolics, yellow earths and structured clays. Other soils which are known or likely to be present include gleyed podzolics on intermittently waterlogged lower slopes, lithosols on steep slopes and shallow hillcrests, and black headland soils (after Parbery 1947) and soloths on very exposed seaward aspects. The soils associated with older sand masses of the lagoon barrier form a catenary sequence from sand podzols on well-drained sites to humus podzols, peaty podzols and then acid peats in swamps. The younger sands associated with foredunes generally display little profile development other than a surface accumulation of organic matter. Along the margins of Wallis Lake the youngest estuarine deposits often display sediment interbedding, but no true profile development. Older estuarine deposits on the other hand display rudimentary pedological development in the form of a surface accumulation of organic matter. These minimally developed, saline soils are solonchaks.

Landuse and fire history

Approximately half (800 ha) of the present national park was originally designated as Booti Booti State Recreation Area in 1977, and this was administered by the NSW Department of Lands and an SRA Trust. Booti Booti SRA was managed for recreational activities such as fishing, swimming and camping, but with regard for intrinsic conservation values. In 1992 the former state recreation area was dedicated as Booti Booti NP under the administration of the NSW National Parks and Wildlife Service. Additions both before and after dedication as a national park have increased the total area to 1586 ha. Booti Booti NP is still managed for both passive recreation and nature conservation. Yahoo Island (48 ha) was dedicated as a nature reserve in 1983, and visitation has not been actively encouraged.

The entire length of Seven Mile Beach in Booti Booti NP was mined for heavy minerals during the period from 1969 to 1975, and mining also occurred at Elizabeth Beach from 1969 to 1970. The mine paths varied in width from approximately 50–350 m. **Casuarina equisetifolia* subsp. *incana* was established on the mined areas beyond what is considered to be its natural southern distribution limit in the vicinity of Laurieton, approximately 70 km to the north (Harden 1990).

Former clearings are evident on the Cape Hawke hill complex, some of which are attributable to abandoned banana plantations dating from about the time of World War II. A wildfire apparently burnt through rainforest on Cape Hawke approximately 60 years ago (D. Turner NPWS, pers. comm. 1999), and fire scars are still evident on many trees.

The fire history of Booti Booti NP and Yahoo NR is reasonably typical of coastal vegetation on the NSW North Coast in that frequent unprescribed fires result from non-natural or unknown sources. Fire records for the two reserves date from 1984, and since this time most of the vegetation in the reserves has been burnt on at least one occasion. The fire records further indicate that a wide variety of vegetation types have been burnt in the last 15 years, including stands of *Livistona australis* rainforest.

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* Exotic or non-indigenous taxa are prefixed with an asterisk.

Fortunately, the extensive rainforests of the Cape Hawke hill complex have remained largely unburnt since 1984. A severe crown fire burnt most of the sand mass vegetation of Booti Booti NP in late January 1997. Yahoo NR last burnt in November 1994, and this fire affected most vegetation types other than dry rainforest on a boulder-strewn knoll.

Previous botanical surveys

Dodkin (1978) and Floyd (1990, undated) investigated the distribution and composition of rainforests in Booti Booti NP and Yahoo NR, while Clough (1979) undertook a more detailed comparative study with rainforests elsewhere on the lower North Coast. Species checklists are available from these earlier works.

The former Booti Booti SRA Trust and the NSW Department of Lands commissioned a more inclusive vegetation study by de Castro Lopo (1980). In this work Booti Booti SRA was divided into six divisions analogous to land systems (e.g. Sand Barriers Division), and 24 subdivisions (e.g. Stabilised Dune Subdivision). A detailed vegetation description and checklist was produced for each subdivision, as well as recommendations for management. In a subsequent publication, de Castro Lopo (1981) presented exploratory analyses of the species checklists compiled for each subdivision, although these analyses were limited by the internal heterogeneity of many of the map units for which the checklists and associated abundance data were collected.

The species checklists produced by Clough (1979), de Castro Lopo (1980), Dodkin (1978) and Floyd (1990, undated) have been incorporated into the present study. Other studies which deal with aspects of the vegetation of the reserves, or the vegetation of other parts of the Wallis Lake area, include the work of Adam et al. (1988, 1989), Brockhoff (1988), Browne and Scott (1985), and Griffith (1987).

Methods

Survey methods

Introduction

The present study is the most recent in a series of 1: 25 000 vegetation maps produced for coastal reserves of northern NSW. This work has been undertaken over a number of years by two of the present authors (S.J. Griffith and R. Wilson) for the NSW National Parks and Wildlife Service. Vegetation maps have been produced for all large coastal reserves of NSW to the north of Booti Booti NP (Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP), and a number of smaller reserves (Ballina NR, Richmond River NR, Iluka NR, Moonee Beach NR, Arakoon SRA, Kattang NR). Several significant areas of coastal vegetation on freehold or crown land have also been mapped, for example the Newrybar sand plain at Lennox Head, lands at Evans Head north and south of the Evans River, lands to the north of Yuraygir NP in the vicinity of Wooloweyah Lagoon, and Frogalla swamp north of Forster (Fig. 2).

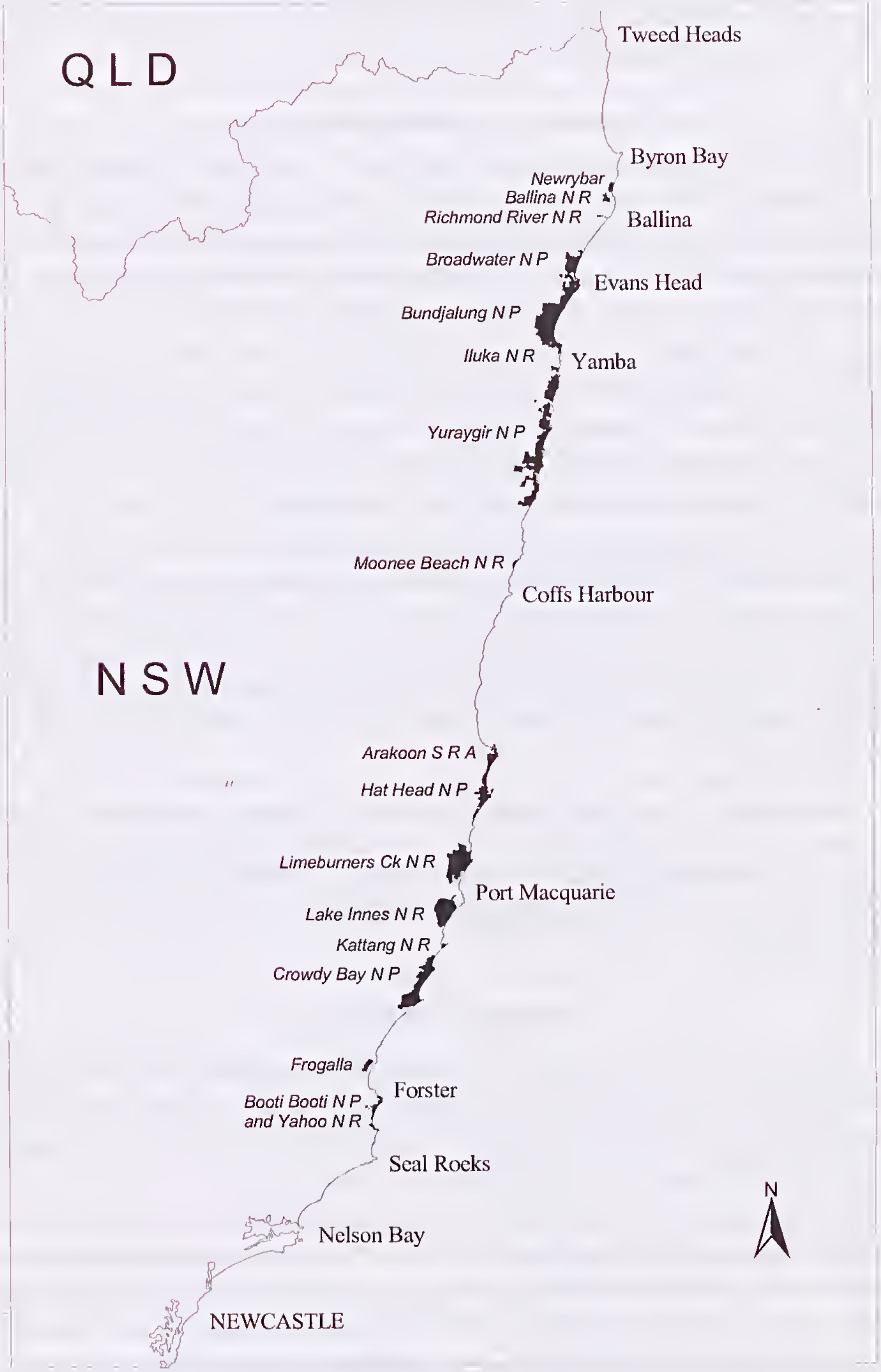


Fig. 2. National parks, nature reserves and other lands on the North Coast of New South Wales for which compatible vegetation mapping is available. These areas of coastal vegetation have been mapped to a scale of 1: 25 000 using the classification and coding system employed in the present study for Booti Booti NP and Yahoo NR.

All of the aforementioned mapping (around 84 000 ha) has been digitised using a minimum polygon size of approximately one hectare, and it is stored in a regional geographical information system (GIS) at the Northern Zone office of the NSW National Parks and Wildlife Service (Coffs Harbour).

Air photo interpretation and mapping

The vegetation of Booti Booti NP and Yahoo NR was mapped by means of air photo interpretation (API). Stereo-paired colour photography flown by the NSW Department of Land and Water Conservation was used, generally at a scale of 1: 25 000 (Bulahdelah series 1991, Runs 6, 7, 8, 9), although an incomplete coverage of 1: 10 000 photography was also used to confirm some vegetation boundaries.

Preliminary stratification of the vegetation into photo types was undertaken by reference to such diagnostic features as colour, texture, crown architecture, aspect and topographic position. A process of preliminary stratification, selective field sampling, and specification and interpretation adjustment was continued until a satisfactory level of confidence in photo type recognition was reached.

Selective field sampling (ground truthing) was undertaken by two people over a period of six days, and during this process observations were made of the structure and composition of each photo type. A species checklist was also compiled for each vegetation type during this fieldwork, although not for rainforests other than that dominated by *Choricarpia leptopetala*. Extensive checklists have already been produced for most rainforest types of the reserves by others (Clough 1979, Dodkin 1978, Floyd 1990, undated).

The boundaries of the photo types, which are generally analogous to plant associations (sensu Beadle 1981), were transcribed to CMA (Central Mapping Authority) 1: 25 000 topographic map bases, digitised, and then converted to ArcView 3.1 GIS (Environmental Systems Research Institute Inc.) format for final vegetation map production.

Vegetation classification

The structural classification used for mapping and community description follows Walker and Hopkins (1984), and the general range in height and crown cover for each community is expressed using two or more classes (e.g. mid-high to tall, open to closed forest; simple, tall to very tall closed fan palm forest).

Subformation names for vegetation types other than rainforest are adapted from the classification proposed by Beadle and Costin (1952), e.g. 'wet sclerophyll forest'. The subformation categories of Floyd (1990) are used for rainforests, although the distinction between littoral rainforest and subtropical rainforest has been maintained.

The communities are named after dominant indicator species of the tallest (dominant) stratum, and most could be considered associations using the definition of Beadle (1981): 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'. In applying Beadle's definition, it is assumed that a particular stand is structurally uniform if it spans two or less height classes (after Walker & Hopkins 1984), and two or less crown cover classes. In this way, for example, *Melaleuca quinquenervia* tall open woodland/woodland could be considered a separate association to *M. quinquenervia* tall open/closed forest. As observed in the field, subsidiary (10–30% of total crown cover) or minor (< 10% of total crown cover) associates of the tallest stratum are given in each plant community description. Emergents above the tallest stratum are also noted where present (generally < 5% of total crown cover for the tallest stratum). For strata beneath the tallest stratum, short lists of common species are provided.

Five-digit numeric codes are used for mapping purposes to identify individual plant communities, and also other map units such as cleared land. The decision to use numeric codes in preference to, say, alpha-numeric codes was originally made in the early 1980s to facilitate the compilation of data for fire behaviour modelling using PREPLAN software. At that time numeric codes were generally easier to manipulate and compute.

The first four digits of each code identify the formation, subformation and community. As an illustration, map codes 0000–4999 are reserved for formations in which the tallest stratum is dominated by trees, i.e. forest and woodland. Within the forest and woodland formations, map codes 3500–3999 are used for communities in the dry sclerophyll forest and woodland subformations. Dry sclerophyll forest and woodland in which *Eucalyptus pilularis* is the dominant indicator species has been assigned the map code 3504. A fifth digit is used on vegetation maps to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. 35041 for *E. pilularis* open to closed forest); 2 = very sparse to sparse (e.g. 35042 for *E. pilularis* open woodland to woodland); 0 = crown cover variable, or else not determined. The '0' code is only used for 'complex' map units and 'miscellaneous' map units.

In some instances it was not possible to map communities discretely at a scale of 1: 25 000. This situation arose where communities were too fragmented and intermixed (e.g. along foredunes and sea cliffs), or else formed seemingly broad ecotones or 'mixed stands' (after Beadle 1981). In many situations where communities closely intermix, micro-relief varies over small distances. For simplicity of mapping, commonly encountered mixed stands which are perceived to comprise two communities have been assigned a distinct map code (e.g. 40991 for mixed swamp sclerophyll forest stands of *Melaleuca quinquenervia* and *Casuarina glauca*). Less common mixed stands are simply mapped using a dual code (e.g. 64021-65031). Fragmented and intermixed vegetation which comprises more than two communities is often found on foredunes, in saltmarshes, and along seacliffs. In such situations appropriately annotated 'complex' map units are employed. These are Foredune Complex (code 90100), Saltmarsh Complex (code 90200) and Headland Complex (code 90300) respectively. 'Miscellaneous' map units are further used to identify artificial, disturbed or predominantly unvegetated areas, for example clearings (code 92030), urban development (code 92090) and open water (code 91040). Occasionally a stand of vegetation grades from one structural formation into another over too small an area to be further subdivided at the mapping scale employed (e.g. where a forest stand grades into tree mallee or shrubland on its more exposed margins). In such cases the stand was mapped according to the predominant growth form.

The vegetation coding system has been consistently applied to vegetation mapping projects in coastal reserves and other lands of northern NSW (Fig. 2), and to date some 180 plant communities have been delineated and mapped. This vegetation classification and mapping system has formed the basis of fire management in many coastal reserves on the NSW North Coast (e.g. NSW National Parks and Wildlife Service 1997, 1998a,b). Sun et al. (1997) provide a generalised comparison of the vegetation classification and mapping system (as 'NSW NPWS Coastal Vegetation Mapping') with systems in use for other parts of NSW and Australia.

Plot-based sampling

Site stratification

A plot-based survey was undertaken in addition to the vegetation mapping, plant community description and species checklist compilation. The stratification of sites for plot-based sampling was initially attempted using environmental variables (geology, slope, aspect, elevation) and a GIS, rather than air photo patterns. Such a procedure has been employed in several other surveys for the NSW National Parks and Wildlife Service (e.g. Bell 1997, Sheringham & Sanders 1993), particularly in vegetation on rugged sandstone landforms in the Sydney region where changes in aspect and elevation are generally pronounced.

Unfortunately, subsequent attempts to assign sample sites using derived environmental category combinations (e.g. high quartz sedimentary bedrock, 0–2° slope, 0–89° aspect and 0–99 m elevation) proved unsatisfactory, primarily due to resolution limitations for the available GIS environmental layers. As an illustration, the GIS geology layer grouped all Pleistocene and Holocene deposits as 'Quaternary sand and alluvium' regardless of origin, degree of weathering, and soil formation environment. Coastal vegetation patterns, particulary on sand plains and around estuaries, are quite complex. In such areas vegetation patterns may change dramatically with only slight changes in elevation (< 0.5 m), and also with variations in groundwater hydrology which are often more closely linked to soil profile characteristics (e.g. depth and degree of induration of the B horizon) than to elevation above sea level.

In view of the perceived complexity of coastal vegetation, and the relative coarseness of the environmental layers which were available at the time of the survey, all attempts to stratify the vegetation using environmental variables were abandoned in favour of sampling a range of photo patterns. Sample sites were assigned by photo pattern following the preparation of a draft vegetation map (Fig. 3).

Data collection

Floristic data were collected for 49 sites in Booti Booti NP and Yahoo NR using quadrats of fixed size (400 m^2 wherever possible, but occasionally 200 m^2 or 100 m^2 in restricted vegetation types). The sampling was undertaken during the periods February to April 1998 and September 1998, and each site was permanently marked with a numbered metal picket. All vascular species present were recorded and assigned to one of six foliage cover (sensu Walker & Hopkins 1984) classes: 1 (< 5%

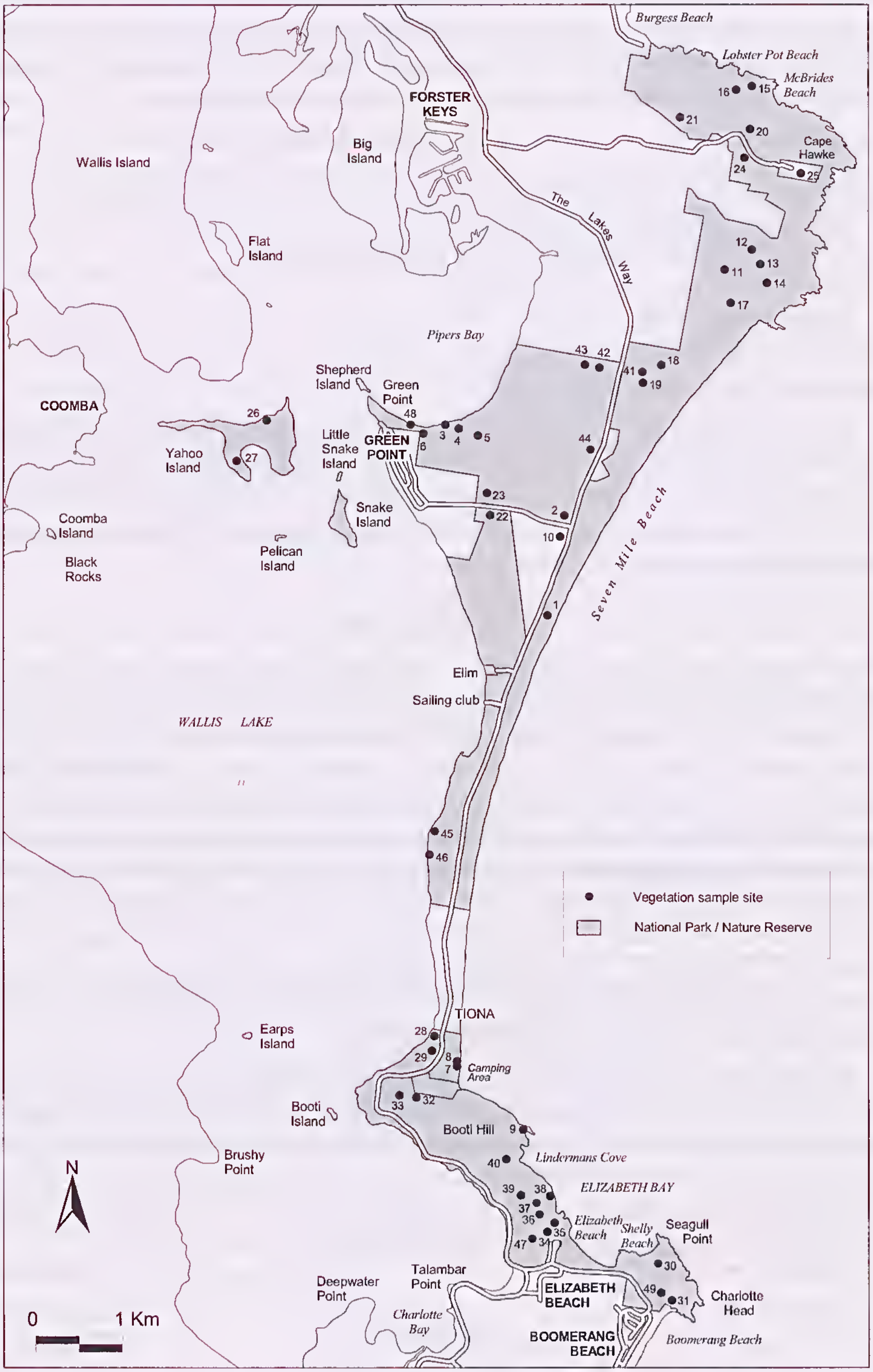


Fig. 3. Location of sites in Booti Booti NP and Yahoo NR at which plot-based sampling was undertaken. Sample sites were stratified on the basis of photo pattern after the preparation of a preliminary vegetation map.

cover and species uncommon); 2 (< 5% and common); 3 (6–20%); 4 (21–50%); 5 (51–75%); and 6 (76–100%). The nomenclature for plant taxa is consistent with current usage at the Royal Botanic Gardens Sydney, and most authorities are provided in Harden (1990–93). Exotic or non-indigenous taxa are prefixed with an asterisk.

The following attributes were also measured or estimated at each site:

- vegetation structure, including the height and foliage cover of each stratum;
- location, aspect, elevation and slope;
- angle to the horizon for the eight principal compass points;
- geology and general soil characteristics;
- topographic position;
- time since the last fire event; and
- forms of disturbance other than fire.

Data are available for all plant communities recognised during the vegetation mapping process, although budgetary constraints restricted the sampling intensity to a single quadrat in all but two communities (two quadrats were placed in each of the latter). The data for each site were recorded on a standard NPWS proforma, and archived with the NPWS, Hunter District.

Numerical analysis

Plant communities perceived from air photo interpretation are primarily distinquished on the basis of structure and, where resolution is adequate, floristic composition of the dominant stratum (and occasionally a second stratum). Plant communities so derived display a degree of floristic homogeneity for the tallest stratum, but this may not be the case for understorey strata. Conversely, it may be possible to distinguish different structural formations on aerial photographs (e.g. shrubland versus heathland), even though there is little obvious difference in floristic composition. All air photo interpretation is also scale dependent, and it is sometimes possible to further subdivide map units with the aid of larger scale photography. The degree of congruence between plant communities derived from air photo interpretation and phytosociological units derived solely from floristics can be examined by the numerical classification of site data.

Forty eight of the 49 sites for which plot-based sampling was undertaken were analysed using the PATN software package (Belbin 1993). One site which sampled young regrowth in a former clearing was excluded from the analysis. The sites were analysed on the basis of full-floristics and foliage cover class scores using the Bray-Curtis dissimilarity measure with the flexible UPGMA (unweighted pair group arithmetic averaging) strategy and a slightly negative (-0.1) beta value.

Results

Introduction

A total of 758 vascular plant taxa have been recorded for Booti Booti NP and Yahoo NR in the present and earlier surveys (Appendix 1). Exotics account for approximately

14% of the flora (104 taxa), although the total number of introduced taxa could be increased with closer examination of disturbed sites (e.g. road verges, picnic areas, former clearings). Disturbed sites were not systematically sampled in the present survey. Further sampling of native vegetation is also likely to increase the number of records of cryptic taxa such as terrestrial orchids.

Of the 654 native taxa known for the reserves, approximately 83% were recorded during fieldwork for the present survey. A similar percentage of native taxa (approximately 78%) is listed in the earlier study of Booti Booti SRA by de Castro Lopo (1980), which includes rainforest records by Clough (1979).

As derived from air photo interpretation and ground survey, 46 plant communities and other vegetation types have been mapped for Booti Booti NP and Yahoo NR (Table 1). This mapping, at a scale of 1: 25 000, is presented as a separate sheet (located in back pocket). The vegetation map is also stored in a GIS maintained by the NSW National Parks and Wildlife Service, both at the Hunter District office (Raymond Terrace) and the Northern Zone office (Coffs Harbour).

In the following discussion each of the plant communities recognised for Booti Booti NP and Yahoo NR is described in terms of its structure, floristic composition, general habitat characteristics, community relations, extent and distribution. This information was compiled using the results of both the plot-based sampling and the fieldwork for vegetation map production. For rainforest communities other than those dominated by *Choricarpia leptopetala*, the descriptions of floristic composition and structure also incorporate information provided by de Castro Lopo (1980), Dodkin (1978) and Floyd (1990, undated).

The distribution of each plant community elsewhere in northern NSW is discussed, primarily by reference to vegetation mapping for other coastal reserves to the north of Booti Booti NP (Fig. 2). Equivalent vegetation types as recognised in other studies are also given where known.

Table 1. Plant communities of Booti Booti National Park and Yahoo Nature Reserve.

The plant communities are named after dominant indicator species of the tallest (dominant) stratum. Five-digit numeric codes are used for mapping purposes to identify individual plant communities. The first four digits of each code identify the formation, subformation and community. A fifth digit (shown in brackets) is used on the vegetation map to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. open to closed forest); 2 = very sparse to sparse (e.g. open woodland to woodland). Missing codes apply to plant communities not found in Booti Booti NP or Yahoo NR.

* Exotic taxa are prefixed with an asterisk.

Plant Community	Structure	Map Code
FORMATION: forest and woodland		**0000-4999**
Subtropical rainforest		**0000-0499**
Livistona australis	simple, tall to very tall closed fan palm forest	0003(1)
Littoral rainforest		**0500-0999**
Cupaniopsis anacardioides	simple, notophyll-microphyll, low to tall closed forest	0502(1)

Plant Community	Structure	Map Code
Drypetes deplanchei-Sarcomelicope simplicifolia subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus*	simple, notophyll-microphyll, low to very tall closed forest	0505(1)
Dry rainforest		**1000-1499**
Ficus spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis*	simple, notophyll, mid-high to tall closed forest	1003(1)
Choricarpia leptopetala	simple, notophyll, low to tall closed forest	1004(1)
Mangrove forest and woodland		**2500-2999**
Avicennia marina subsp. *australasica*	low to mid-high open woodland and woodland	2502(2)
Wet sclerophyll forest		**3000-3499**
Lophostemon confertus	mid-high to very tall, open to closed forest	3002(1)
Eucalyptus grandis	very tall open to closed forest	3004(1)
Eucalyptus pilularis	very tall open to closed forest	3006(1)
Eucalyptus microcorys	very tall open to closed forest	3007(1)
Eucalyptus tereticornis	mid-high to very tall, open to closed forest	3011(1)
Eucalyptus fergusonii subsp. *fergusonii*	tall to very tall, open to closed forest	3012(1)
Corymbia maculata-Eucalyptus fergusonii subsp. *fergusonii-E. acmenoides*	very tall open to closed forest	3013(1)
Dry sclerophyll forest and woodland		**3500-3999**
Eucalyptus pilularis	tall to very tall, open to closed forest	3504(1)
Eucalyptus microcorys	mid-high to very tall, open to closed forest	3508(1)
Eucalyptus tereticornis	mid-high to tall, open woodland to closed forest	3512(1) 3512(2)
Allocasuarina littoralis	low open to closed forest	3513(1)
Angophora costata	mid-high to very tall, open woodland to closed forest	3522(1) 3522(2)
Eucalyptus pilularis-Angophora costata	tall to very tall, woodland to closed forest	3556(1) 3556(2)
Corymbia maculata-Eucalyptus fergusonii subsp. *fergusonii-E. acmenoides*	mid-high to tall, open to closed forest	3559(1)
Eucalyptus tereticornis-E. microcorys	mid-high to very tall, open to closed forest	3560(1)
Angophora floribunda	low to mid-high, open to closed forest	3561(1)
Corymbia maculata	tall to very tall, open to closed forest	3562(1)
Swamp sclerophyll forest and woodland		**4000-4499**
Melaleuca quinquenervia	mid-high to very tall, open woodland to closed forest	4003(1) 4003(2)
Casuarina glauca	mid-high to very tall, open woodland to closed forest	4005(1) 4005(2)
Eucalyptus robusta-Melaleuca quinquenervia	mid-high to very tall, open woodland to closed forest	4098(1) 4098(2)
Melaleuca quinquenervia-Casuarina glauca	mid-high to very tall, open woodland to closed forest	4099(1) 4099(2)
FORMATION: mallee forest and woodland		**5000-5199**
Dry sclerophyll mallee forest and woodland		**5000-5099**

Plant Community	Structure	Map Code
Eucalyptus pilularis	very tall to extremely tall, mallee woodland and open mallee woodland	5002(2)
Swamp sclerophyll mallee forest and woodland		**5100-5199**
Eucalyptus robusta	very tall to extremely tall, mallee woodland and open mallee woodland	5102(2)
FORMATION: shrubland (scrub)		**5200-5599**
Rain-shrubland		**5200-5299**
Choricarpia leptopetala	simple, notophyll, tall to very tall closed shrubland	5203(1)
Dry sclerophyll shrubland		**5400-5499**
Banksia aemula	tall to very tall, open to closed shrubland	5402(1)
Melaleuca armillaris	very tall closed shrubland	5404(1)
Leptospermum laevigatum	tall to very tall closed shrubland	5410(1)
**Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae*	mid-high to tall closed shrubland	5411(1)
Swamp sclerophyll shrubland		**5500-5599**
Melaleuca quinquenervia	tall to very tall, sparse to open shrubland	5506(2)
FORMATION: heathland		**5800-6099**
Dry heathland		**5800-5899**
Banksia aemula-Allocasuarina simulans	mid-high to tall closed heathland	5804(1)
Intermediate dry heathland	mid-high to tall closed heathland	5899(1)
Graminoid clay heathland		**5900-5999**
Banksia spinulosa var. *collina-Allocasuarina littoralis-Hakea teretifolia -Ptilothrix deusta-Themeda australis*	low to mid-high closed heathland	5905(1)
Wet heathland		**6000-6099**
Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva	mid-high to tall closed heathland	6002(1)
FORMATION: chenopod shrubland		**6100-6199**
Sarcocornia quinqueflora subsp. *quinqueflora-Sporobolus virginicus*	dwarf to low, open to closed chenopod shrubland/tussock grassland	6102(1)
FORMATION: tussock grassland		**6200-6299**
Spinifex sericeus	low to mid-high, sparse to closed tussock grassland	6202(1) 6202(2)
FORMATION: sod grassland		**6300-6399**
Themeda australis	low to tall closed sod grassland	6302(1)
FORMATION: sedgeland		**6400-6499**
Baumea juncea	mid-high to tall closed sedgeland	6402(1)
Leptocarpus tenax-Baloskion pallens-Schoenus brevifolius	tall to very tall closed sedgeland	6403(1)
FORMATION: rushland		**6500-6599**
Juncus kraussii subsp. *australiensis*	tall to very tall closed rushland	6502(1)
Phragmites australis	very tall closed rushland	6503(1)

Plant community descriptions

Rainforest

Rainforest vegetation covers approximately 17% of Booti Booti NP and Yahoo NR, where it is found on both Carboniferous strata and unconsolidated Quaternary sediments. Five rainforest communities have been recognised for the reserves, and these represent the dry rainforest and subtropical rainforest subformations distinguished by Floyd (1990), with the latter subformation including littoral rainforest. Approximately one third of the native vascular taxa known for the reserves are found in the rainforests.

Livistona australis subtropical rainforest (map code 00031).

Area: 44 ha in Booti Booti NP and Yahoo NR.

Structure: simple, tall to very tall closed fan palm forest.

Floristic composition: *Livistona australis* dominates the tallest stratum (Fig. 4), although *Casuarina glauca*, *Melaleuca quinquenervia*, *Eucalyptus robusta* and *Lophostemon confertus* may be minor associates (< 10%) or emergent (generally < 5%). Understorey species include *Calochlaena dubia*, *Christella dentata*, *Entolasia marginata*, *Livistona australis*, *Oplismenus aemulus* and *Viola hederacea*, although the immediate ground surface is often largely unvegetated due to shading and litter accumulation.

Habitat and community relations: Primarily occurs on sandy Quaternary sediments along broad open depressions, although also extends into gullies on sedimentary bedrock. Grades into swamp sclerophyll forest, and also into other rainforest communities.

Equivalent vegetation types: Forms part of an *Archontophoenix-Livistona* suballiance circumscribed for NSW by Floyd (1990), and also falls within the broader 'Palm' forest type (No. 7) of the Forestry Commission of NSW (1989). A related *Livistona australis* 'woodland' has been reported for south-eastern Queensland (Elsol & Dowling 1978, McDonald & Elsol 1984).

Distribution in northern New South Wales: Present in Broadwater NP and Hat Head NP. The broader *Archontophoenix-Livistona* suballiance of Floyd (1990) is found in several North Coast reserves, both near and inland of the coastline.

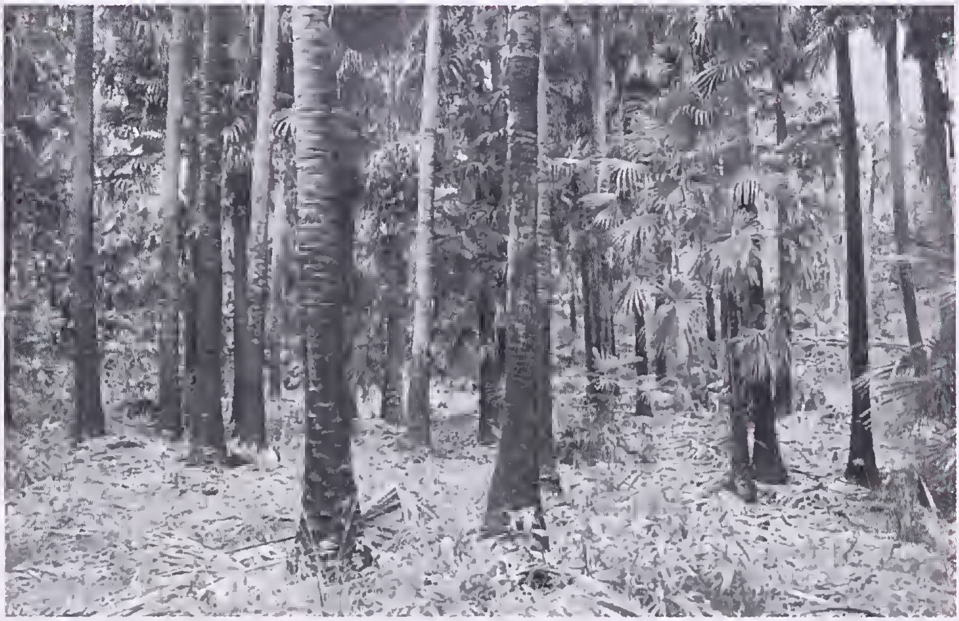


Fig. 4. Subtropical rainforest (simple, tall to very tall closed fan palm forest) dominated by *Livistona australis* (community 00031), with blackened stems from a fire in the 1994/95 fire season. The immediate ground surface is often largely unvegetated due to shading and litter accumulation.

Cupaniopsis anacardioides littoral rainforest (map code 05021).

Area: 11.5 ha in Booti Booti NP, with additional small areas included in a Foredune Complex map unit.

Structure: simple, notophyll-microphyll, low to tall closed forest.

Floristic composition: *Cupaniopsis anacardioides* is characteristic of the equivalent suballiance circumscribed by Floyd (1990), although other tree species which may be locally subsidiary to co-dominant in Booti Booti NP include *Acmena smithii*, *Alectryon coriaceus*, *Banksia integrifolia* subsp. *integrifolia* (which may be more or less emergent), *Drypetes deplanchei*, *Endiandra sieberi*, *Glochidion ferdinandi* var. *ferdinandi*, *Livistona australis*, *Mischocarpus pyriformis* subsp. *pyriformis*, *Planchonella australis* and *Syzygium oleosum*. Vines include *Cissus antarctica*, *Geitonoplesium cymosum*, *Jasminum volubile* and *Stephania japonica* var. *discolor*.

Habitat and community relations: Found in siliceous sand on sheltered aspects of foredune systems, generally quite close to beach fronts. Replaced by other Foredune Complex communities on more exposed aspects.

Equivalent vegetation types: Named after the equivalent suballiance No. 17 of Floyd (1990), and forms part of the broader forest type No. 24 'Tuckeroo' (Forestry Commission of NSW 1989). A comparable *Acronychia imperforata*-*Cupaniopsis anacardioides* closed forest is recognised for south-eastern Queensland (McDonald & Elsol 1984).

Distribution in northern New South Wales: The *Cupaniopsis anacardioides* suballiance of Floyd (1990) extends along the North Coast of NSW where it is reserved in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Myall Lakes NP, Brunswick Heads NR, Broken Head NR, Iluka NR, Moonee Beach NR, Bundagen FR, Limeburners Creek NR, Sea Acres NR and Kattang NR. Additional areas outside of the reserve system are protected under SEPP 26-Littoral Rainforest.

Drypetes deplanchei-*Sarcomelicope simplicifolia* subsp. *simplicifolia*-*Cassine australis* var. *australis*-*Podocarpus elatus* littoral rainforest (map code 05051).

Area: 120 ha in Booti Booti NP where found on Booti Hill and Cape Hawke. Additional minor stands are included in a Headland Complex map unit.

Structure: simple, notophyll-microphyll, low to very tall closed forest.

Floristic composition: *Drypetes deplanchei*, *Sarcomelicope simplicifolia* subsp. *simplicifolia*, *Cassine australis* var. *australis* and *Podocarpus elatus* are characteristic dominants of the equivalent suballiance circumscribed by Floyd (1990), although other species which may be locally subsidiary to co-dominant in Booti Booti NP include *Austromyrtus bidwillii*, *Baloghia inophylla*, *Dysoxylum fraserianum*, *Euroschinus falcata* var. *falcata*, *Heritiera actinophylla* and *Olea paniculata*. Vines include *Arthropteris tenella* and *Cissus antarctica*. *Platycerium bifurcatum* is an abundant epiphyte.

Habitat and community relations: Found on relatively steep, boulder-strewn hillslopes across a range of aspects, although these are predominantly easterly to south-easterly. The sedimentary bedrock is composed of greywacke and tuffaceous sandstone (Floyd 1990). The community is extensive on the southern section of Cape Hawke, but tends to be replaced by *Choricarpia leptopetala* dry rainforest (code 10041) on the northern section where the northerly aspects are perhaps less sheltered and more fire-prone.

Equivalent vegetation types: Named after the equivalent suballiance No. 19 of Floyd (1990), and forms part of the broader forest type No. 25 'Headland Brush Box' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: Floyd (1990) reports the distribution of the suballiance as extending from Gap Beach (Hat Head NP) to Myall Lakes on the NSW North Coast, with a less representative occurrence also present in Royal NP on the Central Coast.

Ficus spp.-*Streblus brunonianus*-*Dendrocnide* spp.-*Cassine australis* var. *australis* dry rainforest (map code 10031).

Area: Occurs on Yahoo NR, and on Booti and Earps Islands in Booti Booti NP. The total area is 7 ha.

Structure: simple, notophyll, mid-high to tall closed forest.

Floristic composition: *Cassine australis* var. *australis*, *Dendrocnide photinophylla*, *Ficus rubiginosa* and *Streblus brunonianus* are some of the characteristic dominants of the equivalent suballiance circumscribed by Floyd (1990), although other species which may be locally subsidiary to co-dominant in Booti Booti NP and Yahoo NR include *Austromyrtus bidwillii*, *Clerodendrum tomentosum*, *Drypetes deplanchei*, *Olea paniculata* and *Planchonella australis*. Vine species include **Anredera cordifolia*, *Cissus antartica*, **Ipomoea cairica*, *Jasminum volubile* and *Malaisia scandens*.

Habitat and community relations: Occurs on boulder outcrops of islands in Wallis Lake. The bedrock is sedimentary, or more specifically tuffaceous sandstone for Yahoo Island (Floyd 1990). The community can be fringed by swamp sclerophyll forest, and at one location adjoins *Livistona australis* subtropical rainforest.

Equivalent vegetation types: Named after the equivalent suballiance No. 23 of Floyd (1990), and forms part of the broader forest type No. 22 'Yellow Tulipwood' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: The *Ficus* spp.-*Streblus brunonianus*-*Dendrocnide* spp.-*Cassine australis* var. *australis* suballiance occurs disjunctly along the North Coast of NSW, and continues further south to Milton (Floyd 1990). Other coastal or island reserves of the North Coast in which the suballiance is present are Myall Lakes NP, John Gould Island NR and Snapper Island NR.

Choricarpia leptopetala dry rainforest (map code 10041).

Area: 99 ha in Booti Booti NP where restricted to Cape Hawke.

Structure: simple, notophyll, low to tall closed forest.

Floristic composition: *Choricarpia leptopetala* dominates the tallest stratum, although *Drypetes deplanchei* and *Lophostemon confertus* may be minor to subsidiary associates (up to 30%), with *L. confertus* becoming more or less emergent at some locations. Understorey and vine species include *Gahnia melanocarpa*, *Notelaea longifolia* forma *intermedia*, *Rapanea variabilis* and *Smilax australis*, although the immediate ground surface may be largely unvegetated due to shading and the presence of extensive rock outcrops.

Habitat and community relations: Extensive on boulder-strewn hillslopes and hillcrests in the northern section of Cape Hawke, particularly on north to north-easterly aspects. At these locations the geology is sedimentary. The community is reduced to the shrubland equivalent (code 52031) on more exposed aspects, and is replaced by *Drypetes deplanchei*-*Sarcomelicope simplicifolia* subsp. *simplicifolia*-*Cassine australis* var. *australis*-*Podocarpus elatus* rainforest (code 05051) along gullies or southerly aspects which are presumably more sheltered and less fire-prone.

Equivalent vegetation types: Named after the *Choricarpia leptopetala* suballiance circumscribed by Floyd (1990), and falls within the broader 'Myrtle' forest type (No. 23) of the Forestry Commission of NSW (1989).

Distribution in northern New South Wales: The *Choricarpia leptopetala* suballiance of Floyd (1990) extends disjunctly along the North Coast of NSW, with limited areas also present on the Central Coast. The suballiance is not known for coastal reserves to the north of Booti Booti NP.

Mangrove woodland

Mangrove vegetation is of very limited extent in Booti Booti NP and Yahoo NR where it occupies approximately 0.15% of the total area. A single community is present, and this is dominated by *Avicennia marina* subsp. *australasica*.

Avicennia marina subsp. *australasica* mangrove woodland (map code 25022).

Area: 2.5 ha in Booti Booti NP and Yahoo NR, with stands in the latter reserve too small to map at a scale of 1: 25 000.

Structure: low to mid-high open woodland and woodland.

Floristic composition: *Avicennia marina* subsp. *australasica* dominates. *Aegiceras corniculatum* is an uncommon understorey shrub. The immediate ground surface is either unvegetated apart from pneumatophores, or else supports lower saltmarsh species such as *Sporobolus virginicus*.

Habitat and community relations: Found on interbedded Quaternary sediments of intertidal flats in the Wallis Lake estuary. Often grades landward into *Sarcocornia quinqueflora* subsp. *quinqueflora*-*Sporobolus virginicus* chenopod shrubland/tussock grassland where inundation by high tides does not occur on a daily basis.

Distribution in northern New South Wales: Occurs in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Ballina NR, Richmond River NR and Limeburners Creek NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: *Avicennia marina* subsp. *australasica* mangrove forest and woodland is widespread along the NSW coast (Beadle 1981, Adam et al. 1988, West et al. 1984), and extends into Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1982, Durrington 1977). The community forms part of forest type No. 33, 'Mangrove' (Forestry Commission of NSW 1989).

Wet sclerophyll forest

Seven wet sclerophyll forest communities have been recognised for Booti Booti NP. As for rainforest, wet sclerophyll forest is found on both Carboniferous strata and unconsolidated Quaternary sediments. Floristically, the wet sclerophyll forests and rainforests of the reserves have much in common. To illustrate this point, approximately half of the native vascular taxa known for the rainforests are also found in wet sclerophyll forests, primarily in understorey strata.

Lophostemon confertus wet sclerophyll forest (map code 30021).

Area: 5.5 ha in Booti Booti NP where restricted to Booti Hill and Charlotte Head.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Lophostemon confertus* dominates the tallest stratum, although *Eucalyptus microcorys* may be a minor associate (< 10%). Understorey and vine species include *Cryptocarya rigida*, *Doodia aspera*, *Lastreopsis decomposita*, *Livistona australis* and *Smilax australis*.

Habitat and community relations: Occurs on south-east to south-west facing hillslopes where the bedrock is sedimentary. Associates with rainforest and *Eucalyptus grandis* wet sclerophyll forest. Replaced by *Eucalyptus pilularis* dry sclerophyll forest on aspects which are likely to be more fire-prone.

Distribution in northern New South Wales: Present in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Iluka NR and Lake Innes NR, although generally as small stands.

Equivalent vegetation types: *Lophostemon confertus* reaches its southern distribution limit in the Hunter River valley on the lower North Coast of NSW (Harden 1991). The community falls within the somewhat broader forest type No. 53 ('Brush Box'), which extends along the coast and escarpment of north-eastern NSW (Forestry Commission of NSW 1989). The community also occurs in south-eastern Queensland (Durrington 1977, Elsol 1991, McDonald & Whiteman 1979, Young & McDonald 1989).

Eucalyptus grandis wet sclerophyll forest (map code 30041).

Area: 8 ha in Booti Booti NP on or near Booti Hill.

Structure: very tall open to closed forest.

Floristic composition: *Eucalyptus grandis* dominates the tallest stratum, although *Corymbia intermedia*, *Eucalyptus microcorys*, *E. pilularis*, *Livistona australis*, *Lophostemon confertus* and *Melaleuca quinquenervia* may be present as minor associates (< 10%) or occasionally subsidiary (up to 30%). Understorey species include *Acacia binervata*, *Baloghia inophylla*, *Cupaniopsis anacardioides*, *Gahnia clarkei*, **Lantana camara* and *Livistona australis*.

Habitat and community relations: Generally occurs along sheltered hillslopes and gullies where the bedrock is sedimentary, although also extends onto sandy Quaternary sediments near the base of Booti Hill. Associates with *Lophostemon confertus* and *Eucalyptus microcorys* wet sclerophyll forests, and at one location also adjoins littoral rainforest. Commonly replaced by *Eucalyptus pilularis* dry sclerophyll forest on less sheltered aspects.

Distribution in northern New South Wales: Present in Broadwater NP, Bundjalung NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR, although generally as very limited stands.

Equivalent vegetation types: *Eucalyptus grandis* reaches its southern distribution limit in the Newcastle area on the lower North Coast (Chippendale 1988, Harden 1991). The community extends north from here along the NSW coast (Beadle 1981, Forestry Commission of NSW 1989, as forest type No. 48 'Flooded Gum'), and is also found in south-eastern Queensland (Elsol & Dowling 1978, McDonald & Whiteman 1979).

Eucalyptus pilularis wet sclerophyll forest (map code 30061).

Area: 7 ha on Booti Hill in Booti Booti NP.

Structure: very tall open to closed forest.

Floristic composition: The tallest stratum is floristically variable, although *Eucalyptus pilularis* accounts for 50% or more of total crown cover.

Subsidiary or co-dominant species include *Eucalyptus grandis*, *E. microcorys*, *E. propinqua* and *Lophostemon confertus*. Understorey species include *Citriobatus pauciflorus*, *Cryptocarya microneura*, *C. rigida*, *Doodia aspera* and *Lophostemon confertus*. Vine species include *Cissus hypoglauca* and *Smilax australis*.

Habitat and community relations: Occurs along south to south-west facing hillslopes and gullies where the bedrock is sedimentary. Grades into *Eucalyptus pilularis* dry sclerophyll forest on less sheltered aspects, with boundaries between the two communities no doubt maintained by fire.

Distribution in northern New South Wales: Found in Bundjalung NP, Yuraygir NP, Hat Head NP, Dooragan NP, Crowdy Bay NP and Lake Innes NR. Also present in many state forests, and some conservation reserves away from the seaboard.

Equivalent vegetation types: *Eucalyptus pilularis* extends north from the Eden district (Harden 1991), although the community is more extensive further north in coastal NSW (Beadle 1981, Forestry Commission of NSW 1989, as forest type No. 36 'Moist Blackbutt'). *Eucalyptus pilularis* wet sclerophyll forest also occurs in south-eastern Queensland (Elsol 1991, McDonald & Elsol 1984, McDonald & Whiteman 1979).

Eucalyptus microcorys wet sclerophyll forest (map code 30071).

Area: 5.5 ha in Booti Booti NP where restricted to Booti Hill and Elizabeth Beach.

Structure: very tall open to closed forest.

Floristic composition: *Eucalyptus microcorys* dominates the tallest stratum, although *Lophostemon confertus* may be a minor associate (< 10%) or subsidiary (up to 30%). Understorey species include *Cryptocarya rigida*, *Diospyros pentamera*, *Doodia aspera*, *Gahnia melanocarpa* and *Livistona australis*.

Habitat and community relations: The main stands occupy south to south-west facing hillslopes where the bedrock is sedimentary. At a single location with little or no aspect the community is found on sandy Quaternary sediments. On less sheltered aspects the community is replaced by *Eucalyptus pilularis* dry sclerophyll forest. At one location the community adjoins rainforest.

Distribution in northern New South Wales: *Eucalyptus microcorys* has a coastal distribution which extends north from the upper Central Coast of NSW into south-eastern Queensland (Chippendale 1988, Harden 1991). The only other coastal reserve on the North Coast of NSW in which the community appears to be present is Lake Innes NR. The equivalent forest type No. 45, 'Tallowwood' is considered to have a restricted distribution in state forests on the North Coast (Forestry Commission of NSW 1989).

Equivalent vegetation types: The Forestry Commission of NSW (1989) recognises a 'Tallowwood' forest type (No. 45).

Eucalyptus tereticornis wet sclerophyll forest (map code 30111).

Area: 7 ha in Booti Booti NP where restricted to the northern section of Cape Hawke.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Eucalyptus tereticornis* dominates. Understorey and vine species include *Cassine australis* var. *australis*, *Choricarpia leptopetala*, *Drypetes deplanchei*, *Gahnia aspera*, *Jasminum volubile* and *Notelaea longifolia* forma *intermedia*.

Habitat and community relations: Occurs on north and north-east facing hillslopes where the bedrock is sedimentary. Replaced by rainforest on increasingly sheltered aspects, and by Headland Complex vegetation on aspects which are more exposed to onshore winds.

Distribution in northern New South Wales: Not known from other coastal reserves in northern NSW, although the dry sclerophyll equivalent (code 35121) is present in Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR and Lake Innes NR.

Equivalent vegetation types: *Eucalyptus tereticornis* forest and woodland extends along the NSW coast and onto the Central Western Slopes (Benson 1989, Forestry Commission of NSW 1989, as forest type No. 92 'Forest Red Gum'), although these occurrences would generally lack a mesophytic understorey. Similar forests and woodlands also occur in south-eastern Queensland (Durrington 1977, Elsol 1991, Elsol & Dowling 1978, Young & McDonald 1989).

Eucalyptus fergusonii subsp. *fergusonii* wet sclerophyll forest (map code 30121).

Area: 4 ha in Booti Booti NP where restricted to the southern end of Cape Hawke.

Structure: tall to very tall, open to closed forest.

Floristic composition: *Eucalyptus fergusonii* subsp. *fergusonii* dominates the tallest stratum, although *E. acmenoides* may be a minor associate (< 10%) or subsidiary (up to 30%). Understorey species include *Diospyros australis*, *Gahnia melanocarpa*, **Lantana camara*, *Lomandra longifolia*, *Macrozamia communis* and *Notelaea longifolia* forma *intermedia*.

Habitat and community relations: Occurs on south and south-east facing hillslopes where the bedrock is sedimentary.

Distribution in northern New South Wales: No other occurrences of the community are known. *Eucalyptus fergusonii* subsp. *fergusonii* has a very sporadic distribution which was previously thought to extend from Morisset to Bulahdelah (Harden 1991).

Equivalent vegetation types: Possibly forms part of forest type No. 84, 'Ironbark' (Forestry Commission of NSW 1989).

Corymbia maculata-Eucalyptus fergusonii subsp. *fergusonii-Eucalyptus acmenoides* wet sclerophyll forest (map code 30131).

Area: 3 ha in Booti Booti NP where restricted to the southern end of Cape Hawke.

Structure: very tall open to closed forest.

Floristic composition: *Corymbia maculata*, *Eucalyptus fergusonii* subsp. *fergusonii* and *Eucalyptus acmenoides* dominate. Understorey species include *Doodia aspera*, *Livistona australis*, *Lomandra longifolia*, *Notelaea longifolia* forma *intermedia*, *Poa labillardieri* and *Pittosporum undulatum*.

Habitat and community relations: Occurs on a south facing hillslope where the bedrock is sedimentary. Grades into *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* dry sclerophyll forest on less sheltered aspects, with boundaries between the two communities no doubt maintained by fire. Replaced by rainforest on increasingly sheltered aspects.

Distribution in northern New South Wales: No other occurrences of the community are known. *Eucalyptus fergusonii* subsp. *fergusonii* has a very sporadic distribution which was previously thought to extend from Morisset to Bulahdelah (Harden 1991).

Equivalent vegetation types: Possibly forms part of forest type No. 74, 'Spotted Gum-Ironbark/Grey Gum' (Forestry Commission of NSW 1989).

Dry sclerophyll forest and woodland

Ten dry sclerophyll forest and woodland communities are recognised for the reserves, and these are found on both sedimentary bedrock and unconsolidated Quaternary sediments. The dry sclerophyll forest and woodland communities share many tallest stratum species in common with the wet sclerophyll forests (e.g. *Corymbia maculata*, *Eucalyptus pilularis*, *E. microcorys*, *E. tereticornis*). Understorey species which are common to the range of dry sclerophyll forests and woodlands include *Imperata cylindrica* var. *major*, *Lomandra longifolia* and *Themeda australis*.

Eucalyptus pilularis dry sclerophyll forest (map code 35041).

Area: 87 ha in Booti Booti NP where restricted to Booti Hill and Charlotte Head.

Structure: tall to very tall, open to closed forest.

Floristic composition: The tallest stratum is floristically variable, although *Eucalyptus pilularis* accounts for 50% or more of total crown cover (Fig. 5). Subsidiary or co-dominant species include *Angophora costata*, *Corymbia intermedia*, *C. maculata*, *Eucalyptus carnea*, *E. microcorys*, *E. propinqua*, *E. resinifera* subsp. *hemilampra* and *E. tereticornis*. Understorey species include *Acacia longifolia*, *Allocasuarina torulosa*, *Imperata cylindrica* var. *major*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Largely restricted to south-westerly aspects on hillslopes where the bedrock is sedimentary. Grades into wet sclerophyll forests of *Eucalyptus grandis*, *E. microcorys* and *E. pilularis* on more sheltered aspects. Often replaced by dry sclerophyll forest dominated by *Eucalyptus microcorys* and/or *E. tereticornis* on seaward aspects.

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Dooragan NP, Crowdy Bay NP, Limeburners Creek NR and Lake Innes NR.

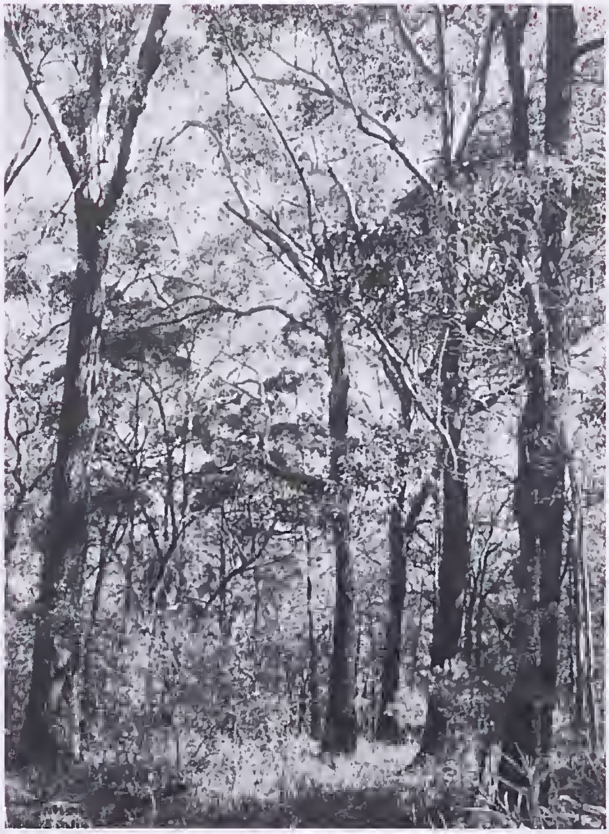


Fig. 5. Dry sclerophyll forest (tall to very tall, open to closed forest) dominated by *Eucalyptus* pilularis (community 35041). Understorey species include *Acacia longifolia, Allocasuarina torulosa, Imperata cylindrica* var. *major, Poa labillardieri* and *Themeda australis.*

Equivalent vegetation types: *Eucalyptus pilularis* extends north from the Eden district on the South Coast of NSW (Harden 1991), and the community is widespread throughout coastal NSW (Beadle 1981, Forestry Commission of NSW 1989, as forest type No. 37 'Dry Blackbutt'). The community also occurs in south-eastern Queensland (Elsol 1991, McDonald & Whiteman 1979).

Eucalyptus microcorys dry sclerophyll forest (map code 35081).

Area: 15.5 ha in Booti Booti NP where restricted to Booti Hill.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Eucalyptus microcorys* dominates the tallest stratum, although *Angophora floribunda, Eucalyptus carnea, E. pilularis, E. resinifera* subsp. *hemilampra* and *E. tereticornis* are minor associates (< 10%). Understorey species include *Acacia maidenii, Imperata cylindrica* var. *major, Poa labillardieri* and *Themeda australis.*

Habitat and community relations: Occurs on hillslopes across a range of aspects where the bedrock is sedimentary. Often grades into *Eucalyptus tereticornis* dry sclerophyll forest or *E. tereticornis-E. microcorys* dry sclerophyll forest (see comment under community 35601). Replaced by *Eucalyptus pilularis* dry sclerophyll forest on aspects facing away from the sea.

Distribution in northern New South Wales: Present in Bundjalung NP, Crowdy Bay NP and Lake Innes NR. The equivalent forest type No. 45, 'Tallowwood' is considered to have a restricted distribution in state forests on the North Coast (Forestry Commission of NSW 1989).

Equivalent vegetation types: *Eucalyptus microcorys* has a coastal distribution which extends north from the upper Central Coast of NSW into south-eastern Queensland (Chippendale 1988, Harden 1991). The equivalent forest type No. 45 is typically a wet sclerophyll forest (Forestry Commission of NSW 1989).

Eucalyptus tereticornis **dry sclerophyll forest and woodland (map codes 35121, 35122).**

Area: 16 ha in Booti Booti NP where largely restricted to Booti Hill and Charlotte Head.

Structure: mid-high to tall, open woodland to closed forest.

Floristic composition: *Eucalyptus tereticornis* dominates the tallest stratum, although *Casuarina glauca*, *Eucalyptus microcorys*, *E. pilularis* and *E. propinqua* may be present as minor associates (< 10%). Understorey species include *Acacia maidenii*, *Imperata cylindrica* var. *major*, *Lomandra longifolia* and *Themeda australis*.

Habitat and community relations: Generally occurs on north to north-easterly aspects of hillslopes where the bedrock is sedimentary, although at one location found on a flat formed from Quaternary sediments. Often grades into *Eucalyptus microcorys* or *E. tereticornis-E. microcorys* dry sclerophyll forest (see comment under community 35601). Replaced by *Eucalyptus pilularis* dry sclerophyll forest on aspects facing away from the sea.

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR and Lake Innes NR, although typically as limited stands.

Equivalent vegetation types: Extends along the coast of NSW, and onto the Central Western Slopes (Benson 1989, Forestry Commission of NSW 1989, as forest type No. 92 'Forest Red Gum'). Also occurs in south-eastern Queensland (Durrington 1977, Elsol 1991, Elsol & Dowling 1978, Young & McDonald 1989).

Allocasuarina littoralis **dry sclerophyll forest (map code 35131).**

Area: Occupies 2.5 ha on Booti Hill and Charlotte Head in Booti Booti NP, with additional small areas included in a Headland Complex map unit.

Structure: low open to closed forest.

Floristic composition: *Allocasuarina littoralis* dominates the tallest stratum, although *Angophora floribunda* and *Eucalyptus tereticornis* may be minor associates (< 10%). Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Entolasia marginata* and *Lomandra longifolia*.

Habitat and community relations: Occupies north-easterly to easterly hillslopes and low hillslopes close to the sea where the bedrock is sedimentary. Often grades into dry sclerophyll forest of *Eucalyptus pilularis*, *E. microcorys* or *E. tereticornis* on less exposed aspects.

Distribution in northern New South Wales: Present in Yuraygir NP, Hat Head NP, Crowdy Bay NP, Richmond River NR, Limeburners Creek NR, Lake Innes NR and Kattang NR.

Equivalent vegetation types: Has a scattered distribution along the North Coast of NSW, and extends to the Central Coast (Benson & Howell 1990). Benson (1989) also reports a community dominated by *Allocasuarina littoralis* for the Northern Tablelands of NSW, and an equivalent *A. littoralis* 'scrub' (Batianoff & Elsol 1989) or 'thicket' (Durrington 1977) occurs in south-eastern Queensland. *Allocasuarina littoralis* 'scrub' is also known for coastal situations in Victoria (Lunt 1998).

Angophora costata **dry sclerophyll forest and woodland (map codes 35221, 35222).**

Area: 7 ha in Booti Booti NP where found on Charlotte Head and the southern end of Cape Hawke.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Angophora costata* dominates the tallest stratum, although *Eucalyptus pilularis* may be a minor associate (< 10%). Understorey species include **Lantana camara*, *Macrozamia communis*, *Pteridium esculentum* and *Xanthorrhoea macronema*.

Habitat and community relations: Occurs in podzolised sand which mantles the sedimentary bedrock of lower hillslopes. Grades into *Eucalyptus pilularis-Angophora costata* dry sclerophyll forest (code 35561), and also adjoins rainforest.

Distribution in northern New South Wales: *Angophora costata* is endemic to NSW where it has a predominantly coastal distribution south from the Evans River (Bale 1992, Harden 1991), although with some major range disjunctions on coastal sand masses (e.g. between the Hastings and Macleay Rivers). To the north of Booti Booti NP, the community occurs in Yuraygir NP and Crowdy Bay NP.

Equivalent vegetation types: Reported for the Myall Lakes area on the lower North Coast of NSW (Myerscough & Carolin 1986), and also for the Central Coast (Benson 1986). The Forestry Commission of NSW (1989) has a 'Smoothbarked Apple' forest type (No. 105) for stands dominated by *Angophora costata* or *A. leiocarpa* (the latter species was formerly included in *A. costata* s. lat.).

Eucalyptus pilularis-Angophora costata dry sclerophyll forest and woodland (map codes 35561, 35562).

Area: 68.5 ha in Booti Booti NP where found on sand masses.

Structure: tall to very tall, woodland to closed forest.

Floristic composition: The tallest stratum is floristically variable, although *Eucalyptus pilularis* accounts for 50% or more of total crown cover. *Angophora costata* is either a minor associate (< 10%), or subsidiary to co-dominant. Understorey species include *Banksia serrata* (which may be more or less continuous in height with the tallest stratum), *Gonocarpus teucrioides*, *Persoonia levis*, *P. linearis*, *Pteridium esculentum*, *Themeda australis* and *Xanthorrhoea macronema*.

Habitat and community relations: Found on well-drained podzolised sands which usually occur as dunes or beach ridges, but occasionally as a mantle over hillslopes where the underlying bedrock is sedimentary. Replaced by swamp sclerophyll forest as soil drainage deteriorates, and by *Eucalyptus pilularis* dry sclerophyll forest (community 35041) on bedrock hills and low hills where a sand mantle is lacking. Adjoins rainforest at some locations.

Distribution in northern New South Wales: Not known for coastal reserves to the north of Booti Booti NP, although a related *Eucalyptus pilularis-Angophora costata/E. gummifera/E. planchoniana* community (code 35061) is found on sand masses in Bundjalung NP, Yuraygir NP and Crowdy Bay NP. To the south of Booti Booti NP, the community occurs in Myall Lakes NP (Myerscough & Carolin 1986).

Equivalent vegetation types: Falls within the broader forest type No. 41, which is commonly referred to as 'Sandhill Blackbutt' (Forestry Commission of NSW 1989). *Eucalyptus pilularis* is ubiquitous in this forest type, with one or two of *Corymbia gummifera*, *C. intermedia*, *Angophora floribunda* and *A. costata* present as associates in varying combinations. Forms part of a *Eucalyptus pilularis-Angophora costata* suballiance circumscribed by Beadle (1981).

Corymbia maculata-Eucalyptus fergusonii subsp. *fergusonii-Eucalyptus acmenoides* dry sclerophyll forest (map code 35591).

Area: 25 ha in Booti Booti NP where restricted to the southern end of Cape Hawke.

Structure: mid-high to tall, open to closed forest.

Floristic composition: *Corymbia maculata*, *Eucalyptus fergusonii* subsp. *fergusonii* and *Eucalyptus acmenoides* dominate. Understorey species include *Lomandra longifolia*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Occurs on sedimentary bedrock of hillslopes and hillcrests with a predominantly north to north-westerly aspect. Grades into *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* wet sclerophyll forest on more sheltered aspects, with boundaries between the two communities no doubt maintained by fire.

Distribution in northern New South Wales: No other occurrences of the community are known. *Eucalyptus fergusonii* subsp. *fergusonii* has a very sporadic distribution which was previously thought to extend from Morisset to Bulahdelah (Harden 1991).

Equivalent vegetation types: Possibly forms part of forest type No. 74, 'Spotted Gum-Ironbark/Grey Gum' (Forestry Commission of NSW 1989).

Eucalyptus tereticornis-Eucalyptus microcorys dry sclerophyll forest (map code 35601).

Area: 29 ha in Booti Booti NP where restricted to Booti Hill.

Structure: mid-high to very tall, open to closed forest.

Floristic composition: *Eucalyptus tereticornis* and *E. microcorys* dominate the tallest stratum, although *Angophora floribunda*, *Corymbia intermedia* and *E. grandis* may be a minor associates (< 10%) or subsidiary (up to 30%). Understorey species include *Acacia maidenii*, *Imperata cylindrica* var. *major*, *Lomandra longifolia*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Occurs on northerly, north-westerly and south-westerly aspects of hillslopes where the bedrock is sedimentary. The community might be considered transitional between dry sclerophyll forest dominated by *Eucalyptus microcorys* (code 35081), and that dominated by *Eucalyptus tereticornis* (code 35121). All three communities occur in close proximity to each other.

Distribution in northern New South Wales: Other occurrences of the community are not known.

Equivalent vegetation types: Not known, although comments made for dry sclerophyll forest in which *Eucalyptus microcorys* (code 35081) or *Eucalyptus tereticornis* (code 35121) is dominant have some relevance.

Angophora floribunda dry sclerophyll forest (map code 35611).

Area: Only present as small stands on Booti Hill in Booti Booti NP, and here all occurrences are included in a Headland Complex map unit.

Structure: low to mid-high, open to closed forest.

Floristic composition: *Angophora floribunda* dominates the tallest stratum, although *Eucalyptus microcorys* may be a minor associate (< 10%). Understorey species include *Breynia oblongifolia*, *Imperata cylindrica* var. *major*, **Lantana camara* and *Pratia purpurascens*.

Habitat and community relations: Occurs on relatively exposed hillslopes close to sea cliffs where the bedrock is sedimentary. Closely associates with other headland vegetation. Replaced by dry sclerophyll forests of *Eucalyptus microcorys*, *E. pilularis* and *E. tereticornis* on less exposed aspects.

Distribution in northern New South Wales: *Angophora floribunda* reaches the northern limit of its coastal distribution in the Hastings River valley (Leach 1986). The community is not known to be reserved elsewhere on the lower North Coast, although a related community (code 35251) in which *Angophora floribunda* associates with *Corymbia intermedia* and *Banksia serrata* is present as limited stands on Quaternary sand in Limeburners Creek NR, Lake Innes NR, Kattang NR and Crowdy Bay NP.

Equivalent vegetation types: Forms part of the broader 'Rough-barked Apples' forest type No. 129 (Forestry Commission of NSW 1989). Forest and woodland in which *Angophora floribunda* dominates has been reported for sedimentary bedrock in Ku-ring-gai Chase National Park on the Central Coast of NSW (Le Brocque & Buckney 1994).

Corymbia maculata dry sclerophyll forest (map code 35621).

Area: 8.5 ha in Booti Booti NP where restricted to Booti Hill.

Structure: tall to very tall, open to closed forest.

Floristic composition: *Corymbia maculata* dominates the tallest stratum, although *C. intermedia* may be a minor associate (< 10%). Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Commelina cyanea*, *Imperata cylindrica* var. *major*, *Poa labillardieri* and *Themeda australis*.

Habitat and community relations: Largely restricted to hillcrests and higher hillslopes, in shallow, stoney soil derived from sedimentary rock. Replaced by *Eucalyptus pilularis* dry sclerophyll forest on sheltered south-westerly hillslopes, and by *E. tereticornis* and *E. microcorys* dry sclerophyll forests on hillslopes with a more northerly aspect. Adjoins rainforest at one location.

Distribution in northern New South Wales: *Corymbia maculata* has a mainly coastal distribution which extends south from the Manning River valley on the mid North Coast (Hill & Johnson 1995), and the community is found in a number of state forests across this distribution (Forestry Commission of NSW 1989).

Equivalent vegetation types: Falls within the *Corymbia maculata* s. lat. alliance of Beadle (1981), and the 'Spotted Gum' (*C. variegata*/*C. maculata*/*C. henryi*) forest type (No. 70) of the Forestry Commission of NSW (1989), both of which are described as widespread in coastal NSW.

Swamp sclerophyll forest and woodland

The swamp sclerophyll forest and woodland communities of Booti Booti NP and Yahoo NR are best developed on Quaternary sediments in areas with impeded drainage. Three species, *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* characterise the tallest stratum, and the understorey supports various helophytes.

Swamp sclerophyll forest and woodland occupies approximately 15% of the reserves, and supports about 11% of the total number of native vascular taxa.

Melaleuca quinquenervia swamp sclerophyll forest and woodland (map codes 40031, 40032).

Area: 156 ha in Booti Booti NP where the largest stands are found in the vicinity of Green Point.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Melaleuca quinquenervia* dominates the tallest stratum, although *Casuarina glauca* and *Eucalyptus robusta* may be present as minor associates (< 10%). Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum* and *Blechnum indicum*.

Habitat and community relations: Generally occupies broad swamps near sea level where the peaty soils overlie sandy Quaternary sediments. Occasionally extends onto seepage areas associated with low hillslopes and gullies over sedimentary bedrock. Commonly grades into swamp sclerophyll forest and woodland of *Eucalyptus robusta* or *Casuarina glauca* (see vegetation types 40981/2 and 40991/2). Also adjoins a range of other vegetation types including sedgeland, heathland and shrubland.

Distribution in northern New South Wales: Present in all major coastal reserves of northern NSW which sample vegetation on Quaternary sediments. Many additional areas outside the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: *Melaleuca quinquenervia* has a coastal distribution in NSW north from Botany Bay on the Central Coast (Harden 1991). The community is particularly widespread on the North Coast, although extensive areas have been cleared for agriculture and urban development (Forestry Commission of NSW (1989), as part of forest type No. 31 'Paperbark', Goodrick 1970, Pressey & Griffith 1992). The community is also found in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977, Elsol & Dowling 1978).

Casuarina glauca swamp sclerophyll forest and woodland (map codes 40051, 40052).

Area: 46.5 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Headland Complex map unit.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Casuarina glauca* dominates the tallest stratum, although *Melaleuca quinquenervia* may be present as a minor associate (< 10%). Understorey and vine species include *Baumea juncea*, **Ipomoea cairica* and *Juncus kraussii* subsp. *australiensis*, although the immediate ground surface is often largely unvegetated due to shading and litter accumulation.

Habitat and community relations: Grows in muddy estuarine sediments of flats associated with the Wallis Lake estuary. Limited areas also occur on exposed aspects of coastal hills and headlands. Often forms a landward fringe to saltmarsh vegetation or, in the absence of the latter, lines the shores of Wallis Lake and its islands. Grades into *Melaleuca quinquenervia* swamp sclerophyll forest and woodland under less saline conditions.

Distribution in northern New South Wales: Found in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Ballina NR, Richmond River NR, Moonee Beach NR, Limeburners Creek NR, Lake Innes NR, Kattang NR and Khappinghat NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: Extends along coastal NSW, although floodplain occurrences have been extensively cleared (Adam et al. 1985, Forestry Commission of NSW (1989), as forest type No. 32 'Swamp Oak', Goodrick 1970). Also present in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978, McDonald & Whiteman 1979).

Eucalyptus robusta-Melaleuca quinquenervia swamp sclerophyll forest and woodland (map codes 40981, 40982).

Area: 28.5 ha in Booti Booti NP.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Eucalyptus robusta* and *Melaleuca quinquenervia* dominate the tallest stratum (Fig. 6). Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Blechnum indicum* and *Gahnia clarkei*.

Habitat and community relations: Occupies broad swamps near sea level where the peaty soils are formed over sandy Quaternary sediments. Often grades into *Melaleuca quinquenervia* swamp forest and woodland, or *Eucalyptus robusta* swamp mallee woodland. Also adjoins *Livistona australis* rainforest.

Equivalent vegetation types: This vegetation type category is used for stands of swamp sclerophyll forest and woodland in which the shift in dominance from *Eucalyptus robusta* to *Melaleuca quinquenervia* occurs over areas which are too small to separate at the mapping scale employed. Such shifts in dominance may be a response to subtle changes in microtopography or drainage, although in some situations *Eucalyptus robusta* and *Melaleuca quinquenervia* seemingly co-occur. This mixing of the two species has also been noted for the Myall Lakes area (Myerscough & Carolin 1986). The vegetation type could be considered a composite of forest type No. 30 'Swamp Mahogany' and forest type No. 31 'Paperbark' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Myall Lakes NP (Myerscough & Carolin 1986), Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Also found on areas of crown or freehold land (e.g. Evans Head, the Newrybar sand plain near Lennox Head, Frogalla Swamp north of Tuncurry).

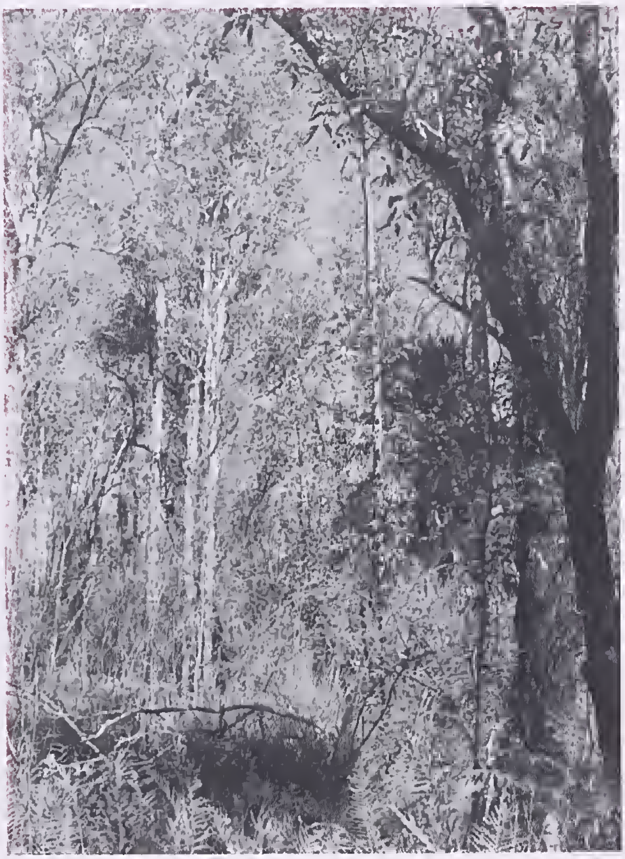


Fig. 6. Swamp sclerophyll forest (tall open forest) dominated by *Melaleuca quinquenervia* and *Eucalyptus robusta* (map code 40981), recovering from a crown fire in late January 1997. *Blechnum indicum* is conspicuous in the ground stratum.

Melaleuca quinquenervia-Casuarina glauca swamp sclerophyll forest and woodland (map codes 40991, 40992).

Area: 18 ha in Booti Booti NP and Yahoo NR.

Structure: mid-high to very tall, open woodland to closed forest.

Floristic composition: *Melaleuca quinquenervia* and *Casuarina glauca* dominate the tallest stratum. Understorey species include *Baumea juncea*, *Eriochloa procera*, *Hemarthria uncinata*, *Lobelia alata* and *Zoysia macrantha*.

Habitat and community relations: Occurs on flats associated with the Wallis Lake estuary where the soils are derived from Quaternary sediments. Limited areas also occur on hillslopes close to the sea where the bedrock is sedimentary. Often associates with other swamp forest and woodland communites, as well as *Livistona australis* rainforest.

Equivalent vegetation types: This vegetation type category is used for stands of swamp sclerophyll forest and woodland in which the shift in dominance from *Melaleuca quinquenervia* to *Casuarina glauca* occurs over areas which are too small to separate at the mapping scale employed. Such shifts in dominance may be a response to subtle changes in microtopography or hydrology, although in some situations *Melaleuca quinquenervia* and *Casuarina glauca* seemingly co-occur. This mixing of the two species has also been noted for the Myall Lakes area (Myerscough & Carolin 1986). The vegetation type could be considered a composite of forest type No. 31 'Paperbark' and forest type No. 32 'Swamp Oak' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Myall Lakes NP (Myerscough & Carolin 1986), Ballina NR, Moonee Beach NR, Limeburners Creek NR, Lake Innes NR and Kattang NR. Also present at numerous locations outside the reserve system, and many of these occurrences are designated as Coastal Wetland under SEPP 14.

Mallee woodland

Limited stands of mallee woodland are found in Booti Booti NP where two communities have been recognised. One community dominated by *Eucalyptus robusta* is found in poorly drained depressions. *Eucalyptus pilularis* dominates the second community, and this is found in a well-drained situation.

Eucalyptus pilularis dry sclerophyll mallee woodland (map code 50022).

Area: 4 ha along The Lakes Way in Booti Booti NP.

Structure: very tall to extremely tall, mallee woodland and open mallee woodland.

Floristic composition: *Eucalyptus pilularis* dominates the tallest stratum, although *Angophora costata* may be a minor associate (< 10%). Understorey species include *Banksia aemula*, *Coleocarya gracilis*, *Hypolaena fastigiata* and *Lomandra glauca*.

Habitat and community relations: Found in a well-drained sand podzol, on the lower slope of a dune where partly sheltered from onshore winds. Replaced by *Banksia aemula-Allocasuarina simulans* dry heathland on more exposed aspects.

Distribution in northern New South Wales: Appears to have a scattered distribution on sand masses of the NSW North Coast, with other occurrences in Broadwater NP, Bundjalung NP, Yuraygir NP, Crowdy Bay NP and Lake Innes NR.

Equivalent vegetation types: None known, although in some respects the community could be considered a structural variant of *Eucalyptus pilularis-Angophora costata* dry sclerophyll forest and woodland (codes 35561/2).

Eucalyptus robusta swamp sclerophyll mallee woodland (map code 51022).

Area: 30.5 ha in Booti Booti NP.

Structure: very tall to extremely tall, mallee woodland and open mallee woodland.

Floristic composition: *Eucalyptus robusta* dominates. Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Dianella caerulea*, *Imperata cylindrica* var. *major* and *Leptospermum polygalifolium*.

Habitat and community relations: Found in peaty soils along open depressions associated with beach ridges and dunes. Often grades upslope into *Banksia aemula* dry sclerophyll shrubland or *B. aemula-Allocasuarina simulans* dry heathland.

Distribution in northern New South Wales: Limited areas occur in Broadwater NP, Crowdy Bay NP, Moonee Beach NR and Lake Innes NR. Small stands also occur on areas of crown or freehold land (e.g. Evans Head, and the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: Although the range of *Eucalyptus robusta* extends along much of the NSW coast (Harden 1991), this mallee community appears to have a very scattered distribution (e.g. Murray 1989, Pressey & Griffith 1992).

Shrubland

Shrubland vegetation is typically greater than 2 m in height, and supports a tallest stratum dominated by woody plants which are multistemmed at or near the base. Occasionally shrublands are less than 2 m high (cf. heathland) where dominated by species which are better classified as shrubs rather than heath shrubs using the criteria of Walker and Hopkins (1984). Shrublands are found in a range of habitats throughout Booti Booti NP, and the following six communities have been recognised for rain-shrubland, dry sclerophyll shrubland and swamp sclerophyll shrubland subformations.

Choricarpia leptopetala rain-shrubland (map code 52031).

Area: 3 ha in Booti Booti NP where restricted to the northern section of Cape Hawke.

Structure: simple, notophyll, tall to very tall closed shrubland.

Floristic composition: *Choricarpia leptopetala* is more or less mono-dominant. Understorey species include *Gahnia aspera* and *Gymnostachys anceps*, although the immediate ground surface is largely unvegetated due to shading and the presence of extensive rock outcrops.

Habitat and community relations: Occupies east and north-east facing hillslopes where exposed to onshore winds. The substrate is sedimentary rock, and this outcrops extensively as boulders. Grades into the forest equivalent, *Choricarpia leptopetala* dry rainforest, on less exposed aspects.

Equivalent vegetation types: A structural variant of the *Choricarpia leptopetala* dry rainforest suballiance circumscribed by Floyd (1990), which extends to the Central Coast of NSW. The suballiance forms part of forest type No. 23, 'Myrtle' (Forestry Commission of NSW 1989).

Distribution in northern New South Wales: The *Choricarpia leptopetala* suballiance of Floyd (1990) extends disjunctly along the North Coast of NSW, although it is not present in other coastal reserves to the north of Booti Booti NP.

Banksia aemula dry sclerophyll shrubland (map code 54021).

Area: 72 ha in Booti Booti NP.

Structure: tall to very tall, open to closed shrubland.

Floristic composition: *Banksia aemula* is the characteristic dominant of the tallest stratum. *Boronia pinnata*, *Leptospermum polygalifolium*, *L. trinervium*, *Melaleuca nodosa*, *Pteridium esculentum* and other species form a somewhat continuous understorey, certain of which (e.g. *L. polygalifolium*, *L. trinervium*) may merge and associate with *B. aemula* in the absence of fire for long periods. At some locations *Eucalyptus robusta* is present as a scattered tree mallee emergent (< 5%).

Habitat and community relations: Grows in sand podzol soils of beach ridges and dunes. Replaced by *Banksia aemula-Allocasuarina simulans* dry heathland on more exposed aspects. Often replaced downslope by wet heathland, swamp sclerophyll forest, or *Eucalyptus robusta* swamp sclerophyll mallee woodland.

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR and Limeburners Creek NR. Also present on areas of freehold or crown land (e.g. the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: Widespread on the North Coast of NSW, and extends to the Central Coast (Benson & Howell 1990). Also occurs in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977).

Melaleuca armillaris dry sclerophyll shrubland (map code 54041).

Area: 6.5 ha on headlands in Booti Booti NP, with additional small areas included in a Headland Complex map unit.

Structure: very tall closed shrubland.

Floristic composition: *Melaleuca armillaris* is more or less mono-dominant in the tallest stratum. Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Gahnia aspera* and *Oplismenus imbecillis*, although the immediate ground surface may be largely unvegetated due to heavy shading and the presence of extensive rock outcrops.

Habitat and community relations: Found on relatively steep, south to south-east facing aspects of hillslopes close to the sea. The bedrock is sedimentary, and this outcrops extensively. Associates with several other Headland Complex communities.

Distribution in northern New South Wales: Although *Melaleuca armillaris* has a range which extends into Queensland (Harden 1991), it is not known from coastal headlands of NSW any further north than the Forster area.

Equivalent vegetation types: To the south of Booti Booti NP, the community has been reported for Seal Rocks (Clough 1979). It is also likely to occur elsewhere on the lower North Coast of NSW, as in Myall Lakes NP (Myerscough & Carolin 1986, as part of a 'headland thicket' map unit) and Tomaree NP (Benson 1981, as part of a 'closed-scrub' map unit).

Leptospermum laevigatum dry sclerophyll shrubland (map code 54101).

Area: 26 ha in Booti Booti NP, with additional areas included in Foredune Complex and Headland Complex map units.

Structure: tall to very tall closed shrubland.

Floristic composition: *Leptospermum laevigatum* is more or less mono-dominant in the tallest stratum. Understorey species include **Chrysanthemoides monilifera* subsp. *rotundata*, *Dianella caerulea*, *Lepidosperma concavum* and *Lomandra longifolia*, although the immediate ground surface may be largely unvegetated due to heavy shading.

Habitat and community relations: Grows in well drained siliceous sand of foredunes close to the sea, with limited occurrences also extending onto exposed aspects of bedrock headlands. Associates with a number of other Foredune Complex and Headland Complex communities, although generally replaced by **Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae* shrubland on more exposed aspects along beach fronts.

Distribution in northern New South Wales: Shrubland or forest stands of *Leptospermum laevigatum* occur in Hat Head NP, Crowdy Bay NP, Limeburners Creek NR and Kattang NR. *Leptospermum laevigatum* reaches its natural northern limit of distribution in the Nambucca Heads area (Harden 1991), although it has been planted further north following sand mining.

Equivalent vegetation types: *Leptospermum laevigatum* is a characteristic species of foredune shrublands (and low forests) along parts of southern Australia, including the Central and South Coasts of NSW (Beadle 1981, Bennett 1994).

**Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae* dry sclerophyll shrubland (map code 54111).

Area: Occurs in Booti Booti NP where only mapped as part of a Foredune Complex map unit.

Structure: mid-high to tall closed shrubland.

Floristic composition: **Chrysanthemoides monilifera* subsp. *rotundata* dominates the community, with *Acacia sophorae* present as a subsidiary to minor species (from 30% to < 10%). The immediate ground surface is largely unvegetated due to shading.

Habitat and community relations: Grows in well-drained siliceous sand of Holocene foredunes just above the general zone of influence of high seas. Replaced by *Spinifex sericeus* tussock grassland at lower elevations approaching mean high water level. Often replaced landward by *Leptospermum laevigatum* dry sclerophyll shrubland.

Distribution in northern New South Wales: This community, or the variant *Acacia sophorae* shrubland (code 54081), occurs in all coastal reserves of northern NSW where foredune vegetation is represented.

Equivalent vegetation types: A variant of *Acacia sophorae* shrubland, and only differs in the degree of displacement of *A. sophorae* by the exotic shrub **Chrysanthemoides monilifera* subsp. *rotundata*. *Acacia sophorae* is widespread as a shrubland dominant along the NSW coast (Beadle 1981). *Acacia sophorae* shrubland is also found in south-eastern Queensland (W. McDonald, Queensland Herbarium pers. comm.), although *A. sophorae* reaches its northern distribution limit at Point Arkwright near Coolum (Batianoff & Elsol 1989).

***Melaleuca quinquenervia* swamp sclerophyll shrubland (map code 55062).**

Area: 2.5 ha in Booti Booti NP near the shore of Wallis Lake.

Structure: tall to very tall, sparse to open shrubland.

Floristic composition: *Melaleuca quinquenervia* dominates. Understorey species include *Baumea articulata*, *B. juncea*, *Fimbristylis ferruginea*, *Juncus kraussii* subsp. *australiensis* and *Schoenoplectus litoralis*.

Habitat and community relations: Grows in small swamps near the shore of Wallis Lake where the soil consists of peat over Quaternary sediments. Grades into swamp sclerophyll forest, presumably where drainage improves.

Distribution in northern New South Wales: Occurs in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP and Kattang NR, and also present on areas of freehold or crown land (e.g. the Newrybar sand plain near Lennox Head). Most occurrences are of limited extent.

Equivalent vegetation types: Appears to have a limited distribution in NSW, although heathlands in which *Melaleuca quinquenervia* is dominant or co-dominant are recognised for south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977).

Heathland

Heathland vegetation is less than 2 m in height, and supports a range of woody species, particularly from the families Proteaceae, Myrtaceae, Epacridaceae, Fabaceae and Rutaceae. Heath shrubs often, but not always, have ericoid leaves. Heathland vegetation is widespread in Booti Booti NP but absent from Yahoo NR. Most of the heathlands in Booti Booti NP are found on podzolised Quaternary sands, although a small area of graminoid clay heathland on Charlotte Head is growing in shallow soil derived from sedimentary rock. Approximately 23% of the total number of native vascular taxa recorded for the reserves are found in heathland.

***Banksia aemula-Allocasuarina simulans* dry heathland (map code 58041).**

Area: 89 ha along The Lakes Way in Booti Booti NP.

Structure: mid-high to tall closed heathland.

Floristic composition: *Banksia aemula* and *Allocasuarina simulans* are the characteristic dominants, although other species which may be subsidiary or co-dominant include *Acacia ulicifolia*, *Isopogon anemonifolius*, *Monotoca scoparia* and *Ricinocarpus pinifolius* (Fig. 7).

Habitat and community relations: Grows in sand podzol soils of dunes, on aspects exposed to prevailing onshore winds. Replaced by *Banksia aemula* dry sclerophyll shrubland on more sheltered aspects, and by wet heathland or sedgeland where soil drainage deteriorates.

Distribution in northern New South Wales: *Allocasuarina simulans* is endemic to the Forster-Nabiac area (Harden 1990), and the community is only known for Booti Booti NP.

Equivalent vegetation types: None known, although a related *Banksia aemula-Allocasuarina littoralis* dry heathland community (code 58031) occurs on the NSW North Coast (e.g. in Broadwater NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP and Kattang NR), as well as in south-eastern Queensland (Batianoff & Elsol 1989). For the Central Coast of NSW, McRae (1990) reports *Allocasuarina distyla* as common in *Banksia aemula* heathland of Bouddi Peninsula. *Allocasuarina simulans* was formerly included in *A. distyla* (*Casuarina distyla*) s. lat.

Intermediate dry heathland (map code 58991).

Area: 26.5 ha in Booti Booti NP.

Structure: mid-high to tall closed heathland.

Floristic composition: Intermediate dry heathland supports a mixture of both dry heathland (58041) and wet heathland (60021) species, for example *Banksia aemula*, *B. oblongifolia*, *Dillwynia floribunda* var. *floribunda*, *Hypolaena fastigiata*, *Leptospermum polygalifolium*, *Sporadanthus interruptus*, *Lomandra glauca* and *Melaleuca nodosa*.

Habitat and community relations: Occurs on podzolised sands of deflated dunes where a shallow watertable is present following periods of high rainfall. Intermediate dry heathland is a feature of very deflated sand masses on the NSW North Coast which display little or no slope and aspect. Where the topography becomes more pronounced, intermediate dry heathland is replaced by dry heathland upslope on dunes and beach ridges, and by wet heathland downslope in swales.

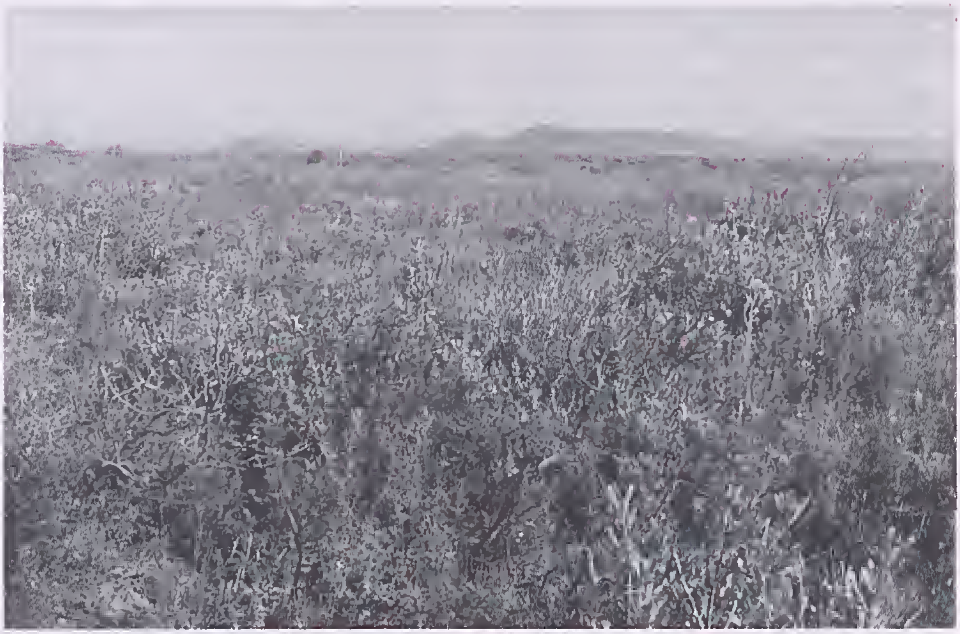


Fig. 7. *Banksia aemula-Allocasuarina simulans* dry heathland (mid-high to tall closed heathland; community 58041) recovering from a severe fire in late January 1997.

Distribution in northern New South Wales: Present in Crowdy Bay NP, Moonee Beach NR and Lake Innes NR. Also found on some areas of freehold or crown land (e.g. the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: For the Myall Lakes area on the lower North Coast of NSW, Myerscough and Carolin (1986) found the boundaries between dry heathland and wet heathland to be somewhat obscure also. Furthermore, for the far North Coast and south-eastern Queensland there are reports of *Banksia aemula* shrubland supporting a ground stratum of 'wet heathland' species in low-lying areas rather than the more typical suite of 'dry heathland' species (Batianoff & Elsol 1989, Griffith 1983).

Banksia spinulosa var. *collina-Allocasuarina littoralis-Hakea teretifolia-Ptilothrix deusta-Themeda australis* graminoid clay heathland (map code 59051).

Area: 2 ha in Booti Booti NP where restricted to the southern section of Charlotte Head.

Structure: low to mid-high closed heathland.

Floristic composition: *Banksia spinulosa* var. *collina*, *Allocasuarina littoralis*, *Hakea teretifolia*, *Ptilothrix deusta* and *Themeda australis* are the characteristic dominants. Other subsidiary to co-dominant species include *Epacris pulchella* and *Gonocarpus tetragynus*. Grasses and sedges form a large component of the above-ground biomass, hence the use of the term 'graminoid'.

Habitat and community relations: Restricted to a steep, south-facing hillslope close to the ocean where exposed to high levels of salt accession. The stoney soil is formed over sedimentary rock. Replaced by forest and woodland on northerly aspects, and also on lower slopes where sand mantles the bedrock. Also adjoins stands of *Melaleuca armillaris* shrubland.

Distribution in northern New South Wales: Not known to occur elsewhere, although closely related communities are discussed below.

Equivalent vegetation types: Forms part of the *Allocasuarina littoralis-Banksia oblongifolia* (syn. *Casuarina littoralis-Banksia aspleniifolia*) 'headland heath' alliance of Beadle (1981). Similar graminoid clay heathland communities are found on headlands and exposed coastal hills elsewhere on the North Coast of NSW. These include a *Banksia oblongifolia-Allocasuarina littoralis-Hakea teretifolia-Aristida warburgii-Ptilothrix deusta* community (code 59031) on rhyolite in Crowdy Bay NP, a *B. oblongifolia-A. littoralis-H. teretifolia-A. warburgii-Themeda australis* community (code 59041) on adamellite in Hat Head NP and Arakoon SRA, and a *B. oblongifolia-A. littoralis-A. warburgii-P. deusta* community (code 59021) on sedimentary rock in Yuraygir NP. Related communities in which *Allocasuarina littoralis* is replaced by *A. distyla* also occur on the lower North Coast (Benson 1981) and Central Coast (McRae 1990). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S.J.G. pers.observ. 1999).

Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva wet heathland (map code 60021).

Area: 34.5 ha in Booti Booti NP.

Structure: mid-high to tall closed heathland.

Floristic composition: Floristically variable, although three or more of *Banksia oblongifolia*, *Leptospermum liversidgei*, *Sporadanthus interruptus*, *Sprengelia sprengelioides* and *Xanthorrhoea fulva* usually co-dominate. Other subsidiary or co-dominant species are *Callistemon citrinus*, *Dillwynia floribunda* var. *floribunda*, *Lepidosperma neesii*, *Lepyrodia scariosa* and *Melaleuca nodosa*. The incidence of fire may explain some of the variation in floristic composition, as certain species are obligate seeders (e.g. *Sprengelia sprengelioides*, *Dillwynia floribunda* var. *floribunda*). Under a suitable fire regime, the serotinous obligate seeder *Banksia ericifolia* var. *macrantha* may overtop lower heath shrub species to form a closed shrubland.

Habitat and community relations: Grows in humus podzol and peaty podzol soils of dune swales where humic groundwater remains close to the ground surface for extended periods. Often replaced by *Banksia aemula-Allocasuarina simulans* dry heathland or *Banksia aemula* dry sclerophyll shrubland upslope as soil drainage improves. Replaced by sedgeland downslope where standing water accumulates.

Distribution in northern New South Wales: Found in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Myall Lakes NP (Myerscough & Carolin 1986), Moonee Beach NR, Limeburners Creek NR, Lake Innes NR and Khappinghat NR. Also present on some areas of freehold or crown land (e.g. Evans Head, and the Newrybar sand plain near Lennox Head).

Equivalent vegetation types: Widespread over much of the NSW North Coast, extending south to the Myall Lakes area (Myerscough & Carolin 1986). Equivalent communities are also recognised for south-eastern Queensland (Batianoff & Elsol 1989, Clifford & Specht 1979, Durrington 1977, Elsol & Dowling 1978). *Leptospermum liversidgei* reaches its southern distribution limit on the lower North Coast at Port Stephens (McNair 1992), as does *Sporadanthus interruptus* (Harden 1993). The remaining three species after which the community is named extend further south (Harden 1991, 1992).

Chenopod shrubland, tussock grassland and sod grassland

Chenopod shrubland, tussock grassland and sod grassland communities are found in what could be considered extreme habitats along estuaries, sea cliffs and beaches. The following three communities have been recognised for Booti Booti NP, and one is also found in Yahoo NR.

Sarcocornia quinqueflora subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland (map code 61021).

Area: 19.5 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit. Occurrences of the community in Yahoo NR are too small to map discretely at a scale of 1: 25 000.

Structure: dwarf to low, open to closed chenopod shrubland/tussock grassland.

Floristic composition: *Sarcocornia quinqueflora* subsp. *quinqueflora* (a chenopod shrub) and *Sporobolus virginicus* (a tussock grass) can co-exist in mixed stands, or alternatively zonation may occur over short distances (with boundaries gradational, and generally unmappable at the scale employed). Occasionally one or other of the two species is mono-dominant over larger areas. *Casuarina glauca* may be present as a scattered emergent (< 5%).

Habitat and community relations: Found on interbedded Quaternary sediments of tidal flats associated with the Wallis Lake estuary (Fig. 8). Often replaced by _Juncus kraussii_ subsp. _kraussii_ rushland upslope, and may be replaced by _Avicennia marina_ subsp. _australasica_ mangrove woodland downslope closer to mean high tide level.

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: This variable community, which could be further subdivided on the basis of relative dominance by the characteristic species (Adam et al. 1988), or else treated as a community complex (Zedler et al. 1995), extends along the NSW coast and into southern Queensland (Adam et al. 1988, Beadle 1981, Dowling & McDonald 1976, Elsol & Dowling 1978).

Spinifex sericeus tussock grassland (map codes 62021, 62022).

Area: Occurs in Booti Booti NP where only mapped as part of a Foredune Complex map unit.

Structure: low to mid-high, sparse to closed tussock grassland.

Floristic composition: _Spinifex sericeus_ dominates, although species which may be subsidiary to minor associates (30% to < 10%) include *_Cakile maritima_, _Carpobrotus glaucescens_, *_Chrysanthemoides monilifera_ subsp. _rotundata_, *_Conyza bilbaoana_, _Scaevola calendulacea_ and _Zoysia macrantha_.

Habitat and community relations: Grows in relatively unstable sands of foredunes just above high water level. Often replaced by *_Chrysanthemoides monilifera_ subsp. _rotundata_-_Acacia sophorae_ shrubland at slightly higher elevations.

Distribution in northern New South Wales: Occurs in all reserves of northern NSW which sample foredune vegetation.

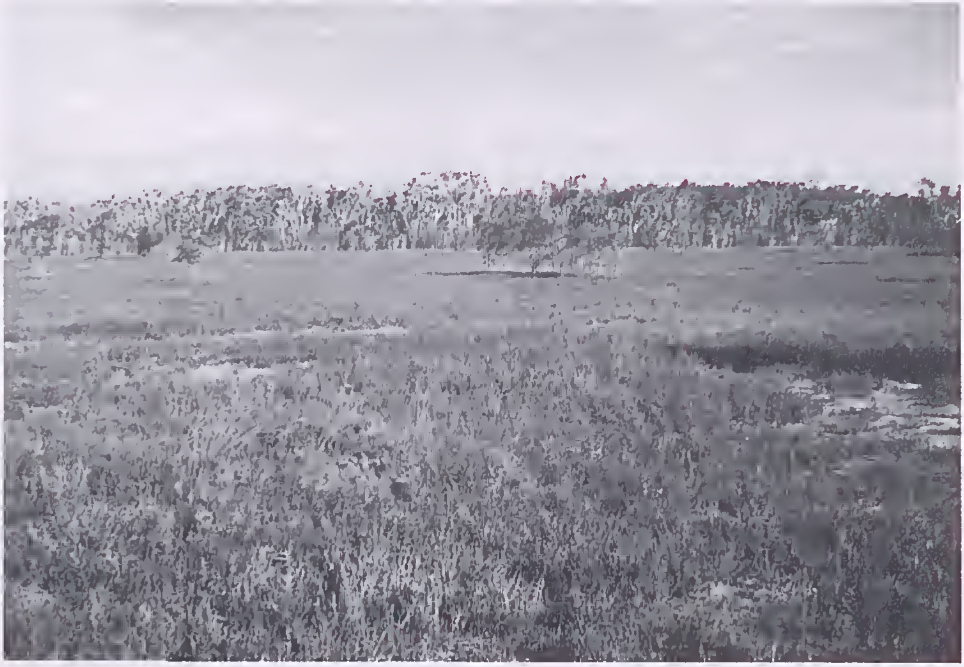


Fig. 8. _Sarcocornia quinqueflora_ subsp. _quinqueflora_-_Sporobolus virginicus_ dwarf to low, open to closed chenopod shrubland/tussock grassland (community 61021) on tidal flats associated with the Wallis Lake estuary.

Equivalent vegetation types: Widespread along the NSW coast (Benson 1989), and also extends into south-eastern Queensland (Batianoff & Elsol 1989, Durrington 1977).

Themeda australis sod grassland (map code 63021).

Area: Occurs in Booti Booti NP where only mapped as part of a Headland Complex map unit.

Structure: low to tall closed sod grassland.

Floristic composition: *Themeda australis* is the characteristic dominant, although closely intertwined heath shrubs, sedges and rushes such as *Abildgaardia ovata*, *Lomandra longifolia* and *Pimelea linifolia* may be subsidiary or minor associates (generally < 10%). Species such as *Banksia integrifolia* subsp. *integrifolia*, *Casuarina glauca*, *Isolepis nodosa* and *Westringia fruticosa* may be present as scattered emergents (< 5%).

Habitat and community relations: Occupies very exposed seaward slopes of headlands, in black headland soils (after Parbery 1947) formed from sedimentary rock under high levels of cyclic salt accession. Replaced by a range of other headland forest and shrubland communities on less exposed aspects.

Distribution in northern New South Wales: Found in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Kattang NR. Also present on a number of headlands outside the reserve system (e.g. Evans Head).

Equivalent vegetation types: Widespread on the North Coast of NSW (Griffith 1992, Quint 1982), and extends further south (Adam et al. 1989, Beadle 1981, Benson 1986, Benson & Howell 1990, McRae 1990). Also occurs in south-eastern Queensland (Batianoff & Elsol 1989).

Sedgeland and rushland

The sedgelands of Booti Booti NP and Yahoo NR are dominated by species from the families Cyperaceae and Restionaceae, whereas the rushlands are dominated by either *Juncus kraussii* subsp. *australiensis* or *Phragmites australis*. Two sedgeland communities and two rushland communities are recognised for the reserves. Collectively these communities support approximately 6% of the native vascular taxa known for the reserves.

Baumea juncea sedgeland (map code 64021).

Area: 24 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit.

Structure: mid-high to tall closed sedgeland.

Floristic composition: *Baumea juncea* dominates. *Sporobolus virginicus* may be present as a shorter but continuous species beneath *B. juncea*. At some locations *Melaleuca quinquenervia* is present as a scattered emergent (< 5%).

Habitat and community relations: Found in solonchak soils of supratidal flats associated with the Wallis Lake estuary. Grades into *Juncus kraussii* subsp. *kraussii* rushland or *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland downslope closer to mean high tide level. Often grades landward into swamp forest or woodland dominated by *Casuarina glauca* and/or *Melaleuca quinquenervia*.

Distribution in northern New South Wales: Present in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: Extends along the Central Coast of NSW (Adam et al. 1988, Kratochvil et al. 1973), and also occurs in Victoria (Head 1988) and south-eastern Queensland (Beadle 1981).

Leptocarpus tenax-Baloskion pallens-Schoenus brevifolius sedgeland (map code 64031).

Area: 36.5 ha in Booti Booti NP, predominantly in the vicinity of Green Point.

Structure: tall to very tall closed sedgeland.

Floristic composition: A floristically variable community. *Leptocarpus tenax*, *Baloskion pallens* and *Schoenus brevifolius* are characteristic dominants, although one (occasionally two) of these may be replaced by such species as *Baumea arthrophylla* and *B. teretifolia*. Certain heath shrubs (e.g. *Callistemon pachyphyllus*, *Melaleuca thymifolia*) can also make a significant contribution to crown cover.

Habitat and community relations: Found in acid peat soils of dunal swamps where standing water is present for extended periods. Replaced by wet heathland and dry heathland upslope as soil drainage improves.

Distribution in northern New South Wales: Present in Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: The community shares many species in common with a somewhat broader *Empodisma minus* (syn. *Calorophus minor*)-*Leptocarpus tenax* alliance described for south-eastern Queensland and NSW by Beadle (1981). *Leptocarpus tenax*, *Baloskion pallens*, *Schoenus brevifolius* and *Baumea teretifolia* are characteristic of a sedgeland community delineated for Tomaree NP on the lower North Coast of NSW by Bell (1997). A related sedgeland of *Leptocarpus tenax*, *Schoenus brevifolius* and other species has been described for the Gosford-Lake Macquarie area on the Central Coast of NSW (Benson 1986). Similar communities also occur in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978).

Juncus kraussii subsp. *australiensis* rushland (map code 65021).

Area: 2.5 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit.

Structure: tall to very tall closed rushland.

Floristic composition: *Juncus kraussii* subsp. *australiensis* dominates. *Sporobolus virginicus* may be present as a shorter but continuous species beneath *J. kraussii* subsp. *australiensis*. *Casuarina glauca* is sometimes present as a scattered emergent (< 5%).

Habitat and community relations: Found on interbedded Quaternary sediments of supratidal flats associated with the Wallis Lake estuary. Often grades into *Baumea juncea* sedgeland upslope, and into *Sarcocornia quinqueflora* subsp. *quinqueflora*-*Sporobolus virginicus* chenopod shrubland/tussock grassland downslope closer to mean high tide level.

Distribution in northern New South Wales: Found in Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP, Moonee Beach NR, Limeburners Creek NR and Lake Innes NR. Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: Widespread on the North Coast of NSW, and extends to the Central and South Coasts (Adam et al. 1988, Beadle 1981, Benson 1986, Goodrick 1970, Kratochvil et al. 1973). Also present in south-eastern Queensland (Batianoff & Elsol 1989, Durrington 1977).

Phragmites australis rushland (map code 65031).

Area: 2 ha in Booti Booti NP and Yahoo NR, with additional small areas included in a Saltmarsh Complex map unit.

Structure: very tall closed rushland.

Floristic composition: *Phragmites australis* dominates. *Baumea juncea*, *Fimbristylis ferruginea* and *Juncus kraussii* subsp. *australiensis* may be present as shorter but continuous species beneath *Phragmites australis*. *Casuarina glauca* can be present as a scattered emergent (< 5%).

Habitat and community relations: Found in solonchak soils of supratidal flats associated with the Wallis Lake estuary. Often grades into *Baumea juncea* sedgeland, and also adjoins swamp sclerophyll forest and woodland.

Distribution in northern New South Wales: Present elsewhere on the mid North Coast in Hat Head NP, Limeburners Creek NR, Lake Innes NR and Khappinghat NR, although generally as very limited stands. Also reported for Myall Lakes NP on the lower North Coast (Myerscough & Carolin 1986). Additional areas outside of the reserve system are designated as Coastal Wetland under SEPP 14.

Equivalent vegetation types: *Phragmites australis* rushland is found on a number of coastal floodplains in northern NSW (Pressey 1981, 1987a,b; Pressey & Griffith 1987), and estuarine occurrences of the community are also reported for NSW by others (e.g. Adam et al. 1988, Brockhoff 1988). A *Phragmites australis* suballiance is recognised by Beadle (1981) for the coast of eastern and south-eastern Australia, and also for some inland rivers and lakes.

Vegetation complexes

Complex map units have been used to delineate groups of plant communities where the individual communities are too small or intermixed to map separately at a scale of 1: 25 000. The following three complex map units have been applied to foredune, saltmarsh and headland vegetation in Booti Booti NP.

Foredune Complex (map code 90100).

The main constituent communities of the Foredune Complex are *Leptospermum laevigatum* dry sclerophyll shrubland (code 54101), **Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae* dry sclerophyll shrubland (code 54111) and *Spinifex sericeus* tussock grassland (codes 62021/2), although limited areas of *Cupaniopsis anacardioides* littoral rainforest (code 05021) and *Melaleuca quinquenervia* swamp sclerophyll forest (code 40031) are also likely.

Other species may also dominate in the Foredune Complex over small areas, for example *Banksia integrifolia* subsp. *integrifolia*, *Carex pumila*, *Lomandra longifolia*, *Scaevola calendulacea* and *Zoysia macrantha*. **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent in the complex, and **Casuarina equisetifolia* subsp. *incana* has been planted at some locations. Much of the complex is regeneration following sand mining.

Saltmarsh Complex (map code 90200).

The main constituent communities of the Saltmarsh Complex are *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland (code 61021), *Baumea juncea* sedgeland (code 64021) and *Juncus kraussii* subsp. *australiensis* rushland (code 65021), with small areas of *Avicennia marina* subsp. *australasica* mangrove woodland (code 25022), *Phragmites australis* rushland (code 65031) and unvegetated mudflat also likely.

Other species may dominate in the Saltmarsh Complex over minor localised areas, for example *Paspalum vaginatum* or *Schoenoplectus litoralis*.

Headland Complex (map code 90300).

The main constituent communities of the Headland Complex are *Allocasuarina littoralis* dry sclerophyll forest (code 35131), *Angophora floribunda* dry sclerophyll forest (code 35611), *Casuarina glauca* swamp sclerophyll forest (code 40051), *Melaleuca armillaris* dry sclerophyll shrubland (code 54041) and *Themeda australis* sod grassland (code 63021). Other communities which are likely to be present in the complex as limited stands are *Livistona australis* subtropical rainforest (code 00031), *Cupaniopsis anacardioides* littoral rainforest (code 05021), *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (code 05051), *Choricarpia leptopetala* dry rainforest (code 10041), *Melaleuca quinquenervia* swamp sclerophyll forest (code 40031), *Choricarpia leptopetala* rain-shrubland (code 52031) and *Leptospermum laevigatum* dry sclerophyll shrubland (code 54101). On very exposed aspects, forest communities may grade into shrublands.

Other species can dominate in the Headland Complex over small localised areas, for example *Banksia integrifolia* subsp. *integrifolia* or *Westringia fruticosa*. **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent in the complex, and exotic grasses such as **Pennisetum clandestinum* occur as localised infestations.

Miscellaneous map units

Miscellaneous map units are used to identify artificial, disturbed or predominantly unvegetated areas, for example clearings (code 92030), urban development (code 92090) and open water (code 91040). Yahoo NR is in a relatively natural state, although approximately 7% of Booti Booti NP is in a cleared or otherwise disturbed condition (road easements and regenerated mine paths excluded), particularly on the Cape Hawke hill complex.

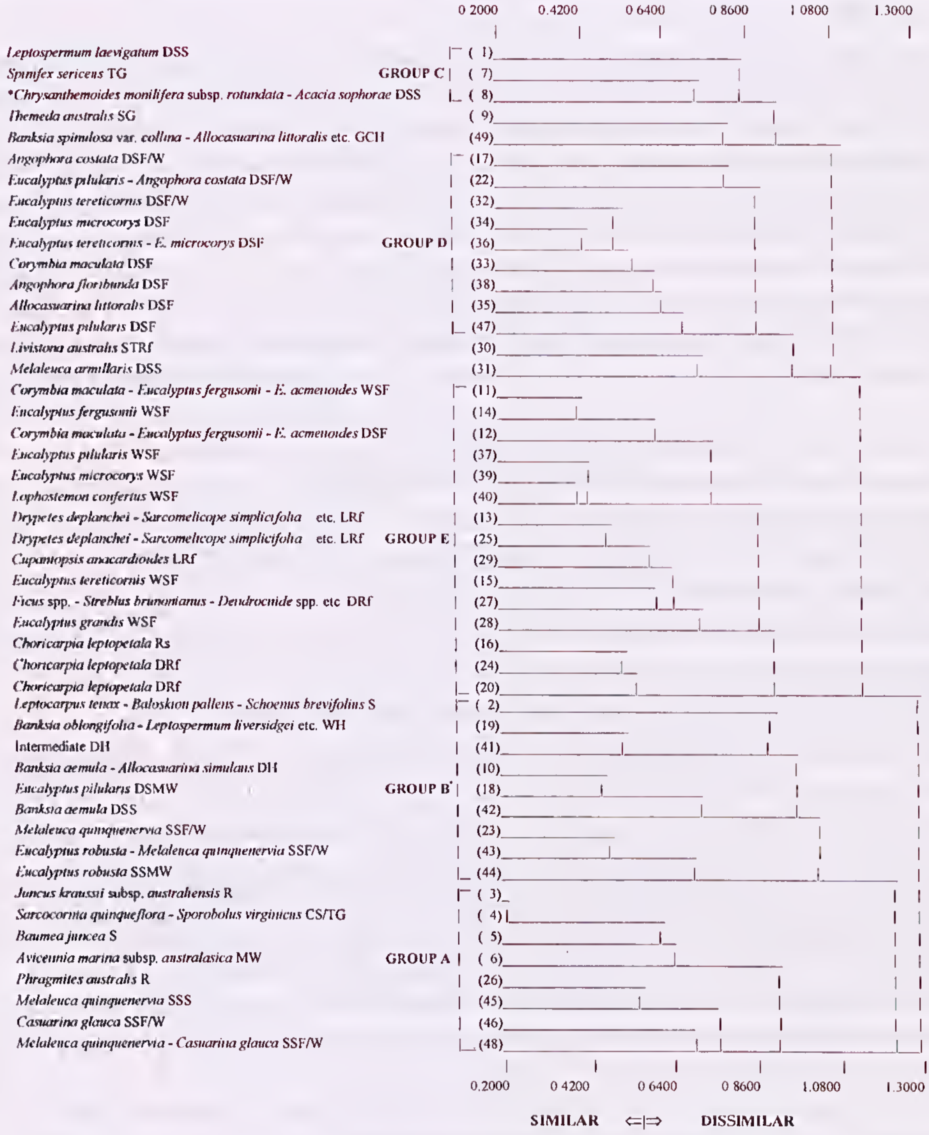
Numerical analysis

The numerical analysis using PATN (Belbin 1993) produced a hierarchical, agglomerative polythetic classification of the 48 plot-based sites. The results are presented as a dendrogram (Fig. 9).

In the interpretation of hierarchical classifications such as the one produced here, any decision as to the selection of the most meaningful number of final floristic groups is still subjective and largely rests on the current level of ecological understanding (see Kent & Coker 1992). This dilemma is further compounded by a lack of sample site replication, as is the case in the present study other than for *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (Sites 13 and 25) and *Choricarpia leptopetala* dry rainforest (Sites 20 and 24).

If, for arguments sake, the number of floristic groups were to be constrained at the level for which the replicate rainforest sites combine (dissimilarity coefficient of approximately 0.55 on Fig. 9), a number of other sites also merge. These groups of merging sites include:

- Sites 32, 34 and 36: *Eucalyptus tereticornis* dry sclerophyll forest/woodland (DSF/W), *E. microcorys* DSF and *E. tereticornis-E. microcorys* DSF, all of which have obvious tallest stratum affinities, and many understorey species in common;
- Sites 11 and 14: *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* wet sclerophyll forest (WSF) and *E. fergusonii* subsp. *fergusonii* WSF, which have tallest stratum affinities, and many understorey species in common;
- Sites 37, 39 and 40: *Eucalyptus pilularis* WSF, *E. microcorys* WSF and *Lophostemon confertus* WSF, all of which share many common understorey species, with the tallest stratum species also interchanging as subsidiary or minor associates rather than dominants (e.g. *E. microcorys* as a subsidiary or minor tallest stratum species in *E. pilularis* WSF and *L. confertus* WSF);
- Sites 19 and 41: *Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva* wet heathland and intermediate dry heathland, which are topographically contiguous, and have many species in common;
- Sites 10 and 18: *Banksia aemula-Allocasuarina simulans* dry heathland and *Eucalyptus pilularis* dry sclerophyll mallee woodland, with the latter having an understorey of typical 'dry heathland' species;
- Sites 23 and 43: *Melaleuca quinquenervia* swamp sclerophyll forest/woodland (SSF/W) and *Eucalyptus robusta-M. quinquenervia* SSF/W, which have tallest stratum affinities, and many understorey species in common;
- Sites 3 and 4: *Juncus kraussii* subsp. *australiensis* rushland and *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland, which are often topographically contiguous, with *S. virginicus* extending beneath *J. kraussii* subsp. *australiensis*;



ABBREVIATIONS:
DSS = Dry Sclerophyll Shrubland
TG = Tussock Grassland
SG = Sod Grassland
GCH = Graminoid Clay Heathland
DSF/W = Dry Sclerophyll Forest/Woodland
STRf = Subtropical Rainforest
WSF = Wet Sclerophyll Forest
LRf = Littoral Rainforest
DRf = Dry Rainforest
Rs = Rain-shrubland
S = Sedgeland
WH = Wet Heathland
DH = Dry Heathland
DSMW = Dry Sclerophyll Mallee Woodland
SSF/W = Swamp Sclerophyll Forest/Woodland
SSMW = Swamp Sclerophyll Mallee Woodland
R = Rushland
CS = Chenopod Shrubland
MW = Mangrove Woodland
SSS = Swamp Sclerophyll Shrubland

Fig. 9. Dendrogram showing the relationships between 48 sites in Booti Booti NP and Yahoo NR on the basis of full-floristics and foliage cover class scores using the Bray-Curtis dissimilarity measure.

- Sites 26 and 45: *Phragmites australis* rushland and *Melaleuca quinquenervia* swamp sclerophyll shrubland, which occupy similar habitats and share several species in common.

Based on the above illustration, it would be possible to amalgamate some of the plant communities delineated by means of air photo interpretation. For example, *Eucalyptus tereticornis* DSF/W, *E. microcorys* DSF and *E. tereticornis-E. microcorys* DSF could all be amalgamated into a single map unit. However, it would be unwise to do so given the limited extent of the data set used for analysis, especially where other workers have recognised a difference between, for example *Juncus kraussii* subsp. *australiensis* rushland and *Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus* chenopod shrubland/tussock grassland (Adam et al. 1988, Beadle 1981), or *Eucalyptus pilularis* WSF and *Lophostemon confertus* WSF (Elsol 1991, Forestry Commission of NSW 1989, McDonald & Whiteman 1979), or forests and woodlands of *Eucalyptus tereticornis* and *E. microcorys* (Forestry Commission of NSW 1989). More utilitarian reasons relating to reserve management are also likely to exist for not amalgamating some of the communities derived from air photo interpretation, for example maintaining the distinction between *Melaleuca quinquenervia* SSF/W and *Eucalyptus robusta-M. quinquenervia* SSF/W for the purpose of linking the movement of koalas with the distribution of *Eucalyptus robusta*, a favoured food tree.

Issues of vegetation classification aside, the hierarchical analysis provides some insight into the ecological relationships of the various plant communities defined by air photo interpretation. Some of these relationships are discussed below.

The group of sites comprising Site 3 through to Site 48 (denoted Group A on Fig. 9) are all associated with the Wallis Lake estuary, either as saltmarsh and mangrove vegetation or as fringing swamp forests, swamp woodlands and swamp shrubland.

The group of sites comprising Site 2 through to Site 44 (denoted Group B) are all associated with the older sand mass areas of Booti Booti NP. These sites remain floristically distinct from the foredune communities of Sites 1, 7 and 8 (denoted Group C).

Banksia spinulosa var. *collina-Allocasuarina littoralis-Hakea teretifolia-Ptilothrix deusta-Themeda australis* graminoid clay heathland (Site 49) appears to be floristically more similar to *Themeda australis* sod grassland (Site 9) than it is to other heathland communities associated with the old sand masses (Group B). These graminoid clay heathland and sod grassland communities are restricted to exposed aspects of headlands where the soils have formed from sedimentary bedrock.

Despite an obvious overlap in floristic composition for the tallest stratum, the dry sclerophyll forest and woodland communities from Site 17 through to Site 47 (denoted Group D) are more alike with each other than they are with the wet sclerophyll forest (and rainforest) communities in Group E. The one exception is *Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides* DSF (Site 12), which links with the wet sclerophyll forest equivalent (Site 11), and another wet sclerophyll community in which *E. fergusonii* subsp. *fergusonii* dominates in the absence of *Corymbia maculata* (Site 14). This outcome presumably reflects the exclusive fidelity of *E. fergusonii* subsp. *fergusonii* to the communities represented by sites 11, 12 and 14. This species has a very restricted distribution in the reserves where it is confined to Cape Hawke, and it was not recorded in any other communities.

During the field survey for vegetation map preparation, it became apparent that three of the rainforest communities recognised for the reserves using the suballiance typology of Floyd (1990) share many species in common. These three floristically related suballiances are *Cupaniopsis anacardioides* littoral rainforest (Site 29), *Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus* littoral rainforest (Sites 13 and 25), and *Ficus* spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis* dry rainforest (Site 27). The present hierarchical analysis, superficial though it is, would suggest that the aforementioned rainforest suballiances are floristically similar, yet collectively distinct from *Livistona australis* subtropical rainforest (Site 30) and *Choricarpia leptopetala* dry rainforest (Sites 20 and 24).

Significant plant species

Forty four (6.7%) of the 654 native vascular plant taxa recorded for Booti Booti NP and Yahoo NR in the present and earlier surveys are considered to be of conservation significance (Table 2). Five of the taxa, *Allocasuarina defungens*, *A. simulans*, *Chamaesyce psammogeton*, *Cynanchum elegans* and *Senna acclinis*, are listed under the *NSW Threatened Species Conservation (TSC) Act 1995*. A sixth taxon, *Eucalyptus fergusonii* subsp. *fergusonii*, is listed on the Rare or Threatened Australian Plants (ROTAP) schedule (after Briggs & Leigh 1996). The remaining 38 taxa either approach or reach their distribution limit in the reserves, or are in some way restricted.

A further five taxa of Booti Booti NP, although widespread on coastal sand masses in northern NSW nonetheless reach their southern distribution limit in the Port Stephens area of the lower North Coast, approximately 60 km to the SSW. These taxa are: *Aotus lanigera* (Bell 1997), which was previously thought to extend northwards from Taree (Harden 1991); *Leptospermum liversidgei* (McNair 1992), previously known as far south as Myall Lakes (Harden 1991); *Sporadanthus interruptus* (Harden 1993); *Leucopogon lanceolatus* var. *gracilis* (Harden 1992); and *Leucopogon leptospermoides* (Harden 1992).

Management issues

Fire

Fire management in Booti Booti NP and Yahoo NR will largely be a matter of fire exclusion in the short term, in view of the extent and severity of fires in the last 5–10 years. For the longer term there is a relative paucity of habitat-specific information about the fire behaviour of individual plant species in the reserves other than general post-fire regeneration responses (e.g. Griffith & Williams 1997). Little is also known about the impact of season of burn, the extent to which post-fire weather patterns influence recruitment, and the significance of fire heterogeneity and micro-site variation. Nonetheless, in the absence of further research it is possible to apply generalised fire interval classes to the different plant communities of the reserves using guidelines developed by the NSW National Parks and Wildlife Service (refer NSW National Parks and Wildlife Service 1997, 1998a,b). Mitigating factors which relate to the generalised fire interval classes are discussed at length in Griffith et al. (1999). These mitigating factors include post-fire weed encroachment, the proximity of 'fire-tolerant' vegetation to 'fire-sensitive' vegetation, the likely impact of peat fires, the severity of a recent unplanned crown fire, anecdotal evidence for already depleted seed pools in certain obligate seed regenerator species, the fire behaviour of significant plant species, and likely shifts in floristic composition where fire is excluded.

Exotic species

Several particularly aggressive weeds are present in Booti Booti NP and Yahoo NR, and some of these pose a serious threat to the long-term viability of native vegetation. **Chrysanthemoides monilifera* subsp. *rotundata* (Bitou Bush) is present as extensive infestations along foredunes and sea cliffs where it is actively displacing native vegetation. **Lantana camara* (Lantana) is also widespread, particularly in former clearings on the Cape Hawke hill complex and along gullies and moist hillslopes elsewhere. **Anredera cordifolia* (Madeira Vine) is present in dry rainforest on Booti Island and Earps Island in Wallis Lake where it blankets the canopy and ground surface. **Anredera cordifolia* was first reported for Booti Island in 1980 (de Castro Lopo 1980). Another vine, **Ipomoea cairica* (Five-leaf Morning Glory), has the potential to degrade areas of swamp sclerophyll forest and woodland associated with the Wallis Lake estuary. **Ipomoea cairica* forms vine towers on saplings, especially those of *Casuarina glauca*, and this can lead to the death of saplings through competition for sunlight. This may be the case in Yahoo NR where many *Casuarina glauca* stems lie on the ground covered in what appear to be the remains of **Ipomoea cairica*. The shrub **Baccharis halimifolia* (Groundsel Bush) is also considered a threat to the estuarine vegetation of Wallis Lake. Only two plants of this species were observed during the present survey, and both were found in Yahoo NR (and subsequently removed). **Baccharis halimifolia* dominates the understorey of some swamp sclerophyll forests along estuaries on the far North Coast of NSW (e.g. Ballina NR and the Iluka Peninsula), and it has the potential to behave in a similar manner on the lower North Coast. Exotic grasses such as **Pennisetum clandestinum* (Kikuyu) persist in former clearings on headlands close to the sea. Exotic grasses have also invaded severely trampled vegetation, e.g. where 4WD vehicles have damaged *Themeda australis* sod grassland.

Unrestricted access

Unrestricted 4WD vehicle, trail bike and pedestrian access has the potential to further degrade native vegetation, particularly in saltmarsh areas, along foredunes, and in *Themeda australis* sod grassland and graminoid clay heathland on headlands. Rubbish dumping is also a problem along tracks and fire trails where public access is unrestricted.

Table 2. Significant vascular plants of Booti Booti National Park and Yahoo Nature Reserve.

The source of each record is given thus: [1] = recorded during the present survey; [2] = recorded in de Castro Lopo (1980), which includes rainforest data by Clough (1979); [3] = recorded by Floyd (1990, undated); [4] = recorded in Dodkin (1978), [5] = recorded by M. Matthes and A. Bofeldt (in Muggeridge 1999). The general fire response of each taxon (rainforest taxa excluded) is given where known.

ROTAP = Rare or Threatened Australian Plants schedule (after Briggs & Leigh 1996); TSC = NSW Threatened Species Conservation Act (1995).

Species	Significance	Fire Response
Allocasuarina defungens (Casuarinaceae)[1]	Occurs at southern distribution limit in Forster area. Endangered (Schedule 1 of TSC Act; ROTAP 2E).	Resprouts (Griffith & Williams 1997)
Allocasuarina simulans (Casuarinaceae)[1,2]	Endemic to Forster and Nabiac areas in vicinity of Wallis Lake (Harden 1990). Vulnerable (Schedule 2 of TSC Act; ROTAP 2VCa).	Resprouts (Griffith & Williams 1997)
Banksia ericifolia var. *macrantha* (Proteaceae)[1,2]	Restricted to coastal habitats of NSW north from Forster area (Harden 1991).	Adults killed (Griffith & Williams 1997)
Callistemon citrinus (Myrtaceae)[1,2]	Although distribution extends from Victoria to Queensland (Harden 1991), not known to occur on coastal sand masses of NSW to north of Forster area.	Resprouts (Griffith & Williams 1997)
Cassinia aculeata (Asteraceae)[1]	Forster is northern distribution limit (Harden 1992).	Adults killed (Benson & McDougall 1994)
Centratherum punctatum subsp. *australianum* (Asteraceae)[1]	Occurrence in Booti Booti NP represents a southern extension of previously known distribution limit at Wingham, approximately 45 km to NW (Harden 1992).	Not known
Chamaesyce psammogeton (formerly *Chamaesyce sparrmanii*) (Euphorbiaceae)[1]	Uncommon species of sand dunes near the sea, and endemic to Qld, NSW and Lord Howe Island (Harden 1990, Heyligers 1998). Endangered (Schedule 1 of TSC Act).	Not known, but habitat not fire-prone
Cleistanthus cunninghamii (Euphorbiaceae)[1,2,3]	Reaches southern limit of coastal distribution in Booti Booti NP (Floyd 1990).	Rainforest taxon
Coleocarya gracilis (Restionaceae)1	Reaches southern distribution limit in Myall Lakes area, approximately 20 km to SSW (Harden 1993, Myerscough & Carolin 1986).	Resprouts (Griffith & Williams 1997)
Cryptandra ericoides (Rhamnaceae)[1]	Previously only known to occur south from Sydney area (Harden 1990).	Adults killed (S.J.G. pers. observ. 1998)
Cynanchum carnosum (Asclepiadaceae)[1,2,4]	Records for Wallis Lake area represent a` southern extension of previously known distribution limit (Harden 1992).	Not known, but possibly resprouts from rootstock
Cynanchum elegans (Asclepiadaceae)[1]	Endangered (Schedule 1 of TSC Act).	Not known, but possibly resprouts from rootstock
Desmodium nemorosum (Fabaceae)[1,2]	Reaches southern distribution limit in Booti Booti NP (refer Harden 1991).	Not known
Durringtonia paludosa (Rubiaceae)[1]	A monotypic species, endemic to coastal lowlands of northern NSW and south-eastern Qld where restricted to swampy habitats (Harden 1992, Henderson & Guymer 1984).	Resprouts (Griffith & Williams 1997)
Eucalyptus fergusonii subsp. *fergusonii* (Myrtaceae)[1,2,3]	A very sporadic distribution, previously thought to extend from Bulahdelah to Morisset on lower North Coast and upper Central Coast of NSW (Harden 1991). Poorly known (ROTAP 3KC-).	Probably resprouts
Galactia species A (Fabaceae)[1]	Apparently uncommon on North Coast of NSW.	Not known
Ixora beckleri (Rubiaceae)[2,3]	Reaches southern distribution limit in Forster area (Harden 1992).	Rainforest taxon

Species	Significance	Fire Response
Jagera pseudorhus var. *pseudorhus* f. *pseudorhus* (Sapindaceae)[1]	Reaches southern distribution limit in Myall Lakes NP, approximately 20 km to SSW (M. Dodkin, NPWS pers. comm.). Previously known as far south as Black Head, approximately 16 km to the NNW (Floyd 1989).	Rainforest taxon
Kennedia prostrata (Fabaceae)[2]	Occurrence in Booti Booti NP represents a range extension northwards from Port Stephens (Harden 1991) and Myall Lakes (McNair 1992, Myerscough & Carolin 1986) areas of lower North Coast of NSW.	Not known
Keraudrenia hillii var. *hillii* (Sterculiaceae)[2]	Occurrence in Booti Booti NP represents a range extension northwards from Port Stephens (Harden 1990) and Myall Lakes (McNair 1992) on lower North Coast of NSW. Considered rare.	Not known
Leptospermum semibaccatum (Myrtaceae)[1]	Harden (1991) has Forster as southern distribution limit.	Resprouts (Griffith & Williams 1997)
Macrozamia communis (Zamiaceae)[1,2,3]	Has a near-coastal distribution in north of range (Hill 1998). Reaches northern limit at Hallidays Point, approximately 16 km to NNW.	Resprouts (French & Westoby 1996)
Marsdenia lloydii (Asclepiadaceae)[2]	Reaches southern distribution limit in Wang Wauk State Forest, approximately 30 km to WSW (S. Griffith in NPWS database, Northern Zone).	Rainforest taxon
Melaleuca armillaris (Myrtaceae)[1,2]	Although range extends into Queensland (Harden 1991), not known from coastal headlands of NSW any further north than Forster area.	Adults killed (Griffith & Williams 1997)
Monococcus echinophorus (Phytolaccaceae)[2,4]	Reaches southern distribution limit in Forster area, and considered uncommon in NSW (Harden 1990).	Rainforest taxon
Morinda acutifolia (Rubiaceae)[4]	Reaches southern distribution limit in Dungog area, approximately 80 km to WSW (A.G. Floyd in NPWS database, Northern Zone). Considered uncommon in NSW (Harden 1992).	Rainforest taxon
Ochrosperma lineare (Myrtaceae)[1,2]	Harden (1991) has Forster as southern distribution limit.	Adults killed (Griffith & Williams 1997)
Opercularia varia (Rubiaceae)[1]	Records for Booti Booti NP represent a range extension from previously known northern limit in vicinity of Karuah (Harden 1992) and Myall Lakes (Myerscough & Carolin 1986) on lower North Coast of NSW.	Adults killed (Griffith & Williams 1997)
Parietaria debilis (Urticaceae)[2]	Apparently uncommon on North Coast of NSW (refer Harden 1990).	Not known, but an annual species
Parsonsia induplicata (Apocynaceae)[1]	Reaches southern distribution limit at Stroud, approximately 55 km WSW of Booti Booti NP (Harden 1992).	Not known, but possibly resprouts from rootstock
Persoonia katerae (Proteaceae)[1]	Endemic to NSW where found on coastal sands between Hastings River on mid North Coast and Myall Lakes on lower North Coast (Harden 1991).	Not known
Pisonia umbellifera (Nyctaginaceae)[1,2,3]	Considered widespread but not common in coastal NSW (Harden 1990).	Rainforest taxon
Planchonella myrsinoides (Sapotaceae)[1,2,3]	Reaches southern distribution limit in Forster area (Harden 1990).	Rainforest taxon
Poa poiformis (Poaceae)[1]	Records for Yahoo NR and also Kattang NR south of Port Macquarie (S.J.G. pers. observ.) represent a range extension northwards from Port Stephens on lower North Coast of NSW (Harden 1993).	Not known, but possibly resprouts

Species	**Significance**	**Fire Response**
Pterostylis concinna (Orchidaceae)[2]	Occurrence in Booti Booti NP represents a range extension north from Mudgee area on Central Western Slopes of NSW (Harden 1993).	Resprouts
Pultenaea blakelyi (Fabaceae)[1,2]	Records for Booti Booti NP represent a range extension northwards from Myall Lakes, approximately 20 km to the SSW (Harden 1991).	Adults killed (Benson & McDougall 1996)
Randia benthamiana (Rubiaceae)[2,3]	Reaches southern distribution limit in Forster area (Harden 1992).	Rainforest taxon
Ripogonum discolor (Ripogonaceae)[2,3,4]	Reaches southern distribution limit in Myall Lakes area, approximately 20 km to the SSW (Harden 1993).	Rainforest taxon
Senna acclinis (Fabaceae)[5]	Rare (ROTAP 3RC-). Endangered (Schedule 1 of TSC Act).	Rainforest taxon
Tetratheca ericifolia (Tremandraceae)[2]	Distribution extends south from Nabiac area on NW side of Wallis Lake (Harden 1992).	Not known, but possibly resprouts
Tripladenia cunninghamii (Uvulariaceae)[1,2]	Distribution extends north from Myall Lakes area, approximately 20 km to the SSW (Harden 1993).	Not known, but possibly resprouts from a rhizome
Tylophora paniculata (Asclepiadaceae)[1]	Apart from an apparent outlier in Sydney region (A. Bofeldt in NPWS database, Northern Zone), reaches southern distribution limit at Williams River on lower North Coast of NSW (Harden 1992).	Not known, but possibly resprouts from rootstock
Westringia fruticosa (Lamiaceae)[1,2]	Apart from small remnant populations in vicinity of Wallabi Point, approximately 25 km north of Booti Booti NP (S.J.G. pers. observ.), reaches northern distribution limit in Forster area (Harden 1992).	Resprouts (Griffith & Williams 1997)
Xanthosia tridentata (Apiaceae)[1]	Records for Booti Booti NP, Old Bar near Taree (Greater Taree City Council 1996), and Tomaree NP on lower North Coast (Bell 1997) appear to represent a range disjunction northwards from Mount White on Central Coast of NSW (Harden 1992).	Adults killed (Griffith & Williams 1997)

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Appendix 1. Vascular plants of Booti Booti National Park and Yahoo Nature Reserve.

Taxa are listed alphabetically by family and genus within classes. The nomencalture is consistent with current usage at the Royal Botanic Gardens Sydney, and most authorities are given in Harden (1990–93).

The checklist is a compilation of records from the following sources.

[1] = Recorded during the present survey (plot-based sampling and incidental records along foot traverses), or an earlier investigation by Griffith (1987).

[2] = Recorded in a detailed study of the former Booti Booti State Recreation Area by de Castro Lopo (1980). The work of de Castro Lopo also includes rainforest data by Clough (1979).

[3] = Recorded by Floyd (1990, undated).

[4] = Recorded in Dodkin (1978).

[5] = Record of *Senna acclinis* by M. Matthes and A. Bofeldt (in Muggeridge 1999).

A small number of records from sources other than the present survey have not been included in the checklist because they seem doubtful. Any voucher specimens for these records will need to be located and further examined.

Although the checklist is considered comprehensive, further fieldwork is likely to produce additional records for cryptic taxa such as terrestrial orchids. It is also probable that a closer examination of disturbed sites (e.g. roadsides and rest areas) will yield additional records for exotics. Exotic taxa are prefixed with an asterisk.

Index of codes:

The plant communities are named after dominant indicator species of the tallest (dominant) stratum. Each community (or other map unit) has a unique five-digit numeric code. The fifth digit of each code (highlighted in brackets in the index) is used for mapping purposes to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. open to closed forest); 2 = very sparse to sparse (e.g. open woodland to woodland); 0 = crown cover variable, or else not determined. The '0' code is only used for 'complex' map units (e.g. Foredune Complex) and 'miscellaneous' map units (e.g. cleared land). Missing codes apply to plant communities or other map units not found in Booti Booti NP or Yahoo NR.

Map Code	**Plant community or other map unit**
	FOREST AND WOODLAND
	Subtropical rainforest
0003(1)	*Livistona australis*
	Littoral rainforest
0502(1)	*Cupaniopsis anacardioides*
0505(1)	*Drypetes deplanchei-Sarcomelicope simplicifolia* subsp. *simplicifolia-Cassine australis* var. *australis-Podocarpus elatus*
	Dry rainforest
1003(1)	*Ficus* spp.-*Streblus brunonianus-Dendrocnide* spp.-*Cassine australis* var. *australis*
1004(1)	*Choricarpia leptopetala*
	Mangrove forest and woodland
2502(2)	*Avicennia marina* subsp. *australasica*
	Wet sclerophyll forest
3002(1)	*Lophostemon confertus*
3004(1)	*Eucalyptus grandis*
3006(1)	*Eucalyptus pilularis*
3007(1)	*Eucalyptus microcorys*
3011(1)	*Eucalyptus tereticornis*
3012(1)	*Eucalyptus fergusonii* subsp. *fergusonii*
3013(1)	*Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides*
	Dry sclerophyll forest and woodland
3504(1)	*Eucalyptus pilularis*
3508(1)	*Eucalyptus microcorys*
3512(1) 3512(2)	*Eucalyptus tereticornis*
3513(1)	*Allocasuarina littoralis*

Map Code	Plant community or other map unit
3522(1) 3522(2)	*Angophora costata*
3556(1) 3556(2)	*Eucalyptus pilularis-Angophora costata*
3559(1)	*Corymbia maculata-Eucalyptus fergusonii* subsp. *fergusonii-E. acmenoides*
3560(1)	*Eucalyptus tereticornis-E. microcorys*
3561(1)	*Angophora floribunda*
3562(1)	*Corymbia maculata*
	Swamp sclerophyll forest and woodland
4003(1) 4003(2)	*Melaleuca quinquenervia*
4005(1) 4005(2)	*Casuarina glauca*
4098(1) 4098(2)	*Eucalyptus robusta-Melaleuca quinquenervia*
4099(1) 4099(2)	*Melaleuca quinquenervia-Casuarina glauca*
	MALLEE FOREST AND WOODLAND
	Dry sclerophyll mallee forest and woodland
5002(2)	*Eucalyptus pilularis*
	Swamp sclerophyll mallee forest and woodland
5102(2)	*Eucalyptus robusta*
	SHRUBLAND (SCRUB)
	Rain-shrubland
5203(1)	*Choricarpia leptopetala*
	Dry sclerophyll shrubland
5402(1)	*Banksia aemula*
5404(1)	*Melaleuca armillaris*
5410(1)	*Leptospermum laevigatum*
5411(1)	**Chrysanthemoides monilifera* subsp. *rotundata-Acacia sophorae*
	Swamp sclerophyll shrubland
5506(2)	*Melaleuca quinquenervia*
	HEATHLAND
	Dry heathland
5804(1)	*Banksia aemula-Allocasuarina simulans*
5899(1)	Intermediate dry heathland
	Graminoid clay heathland
5905(1)	*Banksia spinulosa* var. *collina-Allocasuarina littoralis-Hakea teretifolia-Ptilothrix deusta-Themeda australis*
	Wet heathland
6002(1)	*Banksia oblongifolia-Leptospermum liversidgei-Sporadanthus interruptus-Sprengelia sprengelioides-Xanthorrhoea fulva*
	CHENOPOD SHRUBLAND
6102(1)	*Sarcocornia quinqueflora* subsp. *quinqueflora-Sporobolus virginicus*
	TUSSOCK GRASSLAND
6202(1) 6202(2)	*Spinifex sericeus*
	SOD GRASSLAND
6302(1)	*Themeda australis*
	SEDGELAND
6402(1)	*Baumea juncea*
6403(1)	*Leptocarpus tenax-Baloskion pallens-Schoenus brevifolius*
	RUSHLAND
6502(1)	*Juncus kraussii* subsp. *australiensis*
6503(1)	*Phragmites australis*

Map Code	Plant community or other map unit
	VEGETATION COMPLEXES
9010(0)	Foredune Complex
9020(0)	Saltmarsh Complex
9030(0)	Headland Complex
	MISCELLANEOUS MAP UNITS
9102(0)	Beach sand, mobile sand (occasionally sandy tidal flats)
9103(0)	Rock
9104(0)	Open water
9202(0)	Partially cleared
9203(0)	Cleared
9204(0)	Disturbance associated with past mining (includes quarries)
9206(0)	Picnic or camping area
9207(0)	Disturbance associated with roads
9208(0)	Disturbance associated with transmission line
9209(0)	Urban or residential development and associated infrastructure (includes housing, public works etc.)

	Plant community or other map unit in which found
CLASS LYCOPSIA	
Lycopodiaceae	
Lycopodiella cernua[1]	05021
Selaginellaceae	
Selaginella uliginosa[1,2]	58991 60021
CLASS FILICOPSIDA	
Adiantaceae	
Adiantum aethiopicum[1,2]	35041
Adiantum formosum[2]	
Adiantum hispidulum[1,2,4]	00031 10031 30131
Adiantum silvaticum[2,3]	05051
Cheilanthes austrotenuifolia[1,2]	35131
Pellaea falcata[1,2,3,4]	00031 05021 05051 10031 35121 35122 35621
Pellaea paradoxa[1,2,3]	05051 30131 35591
Aspleniaceae	
Asplenium attenuatum[2,3]	05051
Asplenium australasicum[2,3,4]	05051 10031
Asplenium difforme[1]	91030
Blechnaceae	
Blechnum camfieldii[2]	
Blechnum cartilagineum[1,2]	30021 30061 30071 35041
Blechnum indicum[1,2]	30041 40031 40032 40981 40982 51022 64031
Blechnum patersonii[2]	
Doodia aspera[1,2,3,4]	05051 10031 30021 30061 30071 30121 30131
Culcitaceae	
Calochlaena dubia[1,2]	00031 30021 30041 30071 35041 35561 35562
Cyatheaceae	
Cyathea australis[2]	
Cyathea leichhardtiana[2]	
Davalliaceae	
Arthropteris tenella[1,2,3]	05051
Davallia solida var. *pyxidata*[2,3,4]	05051 10031
**Nephrolepis cordifolia*[1]	92070

Dennstaedtiaceae	
Histiopteris incisa[2]	
Hypolepis muelleri[1,2,4]	00031 30071 35081 40051 40052
Pteridium esculentum[1,2,3,4]	00031 30021 30061 30121 35041 35081 35131 35221 35222 35561 35562 35591 35611 35621 40031 40032 40981 40982 51022 54021
Dryopteridaceae	
Arachniodes aristata[2]	
Lastreopsis acuminata[2]	
Lastreopsis decomposita[1,2,3]	05021 05051 30021
Lastreopsis microsora subsp. *microsora*[1,2]	05051
Lindsaeaceae	
Lindsaea linearis[1,2]	59051
Polypodiaceae	
Platycerium bifurcatum[1,2,3]	05021 05051 10031 30061 30121 30131
Pyrrosia confluens var. *confluens*[1,2,4]	05051 10031
Pteridaceae	
Pteris tremula[2,3]	05051
Schizaeaceae	
Schizaea bifida[1]	58041
Thelypteridaceae	
Christella dentata[1,2,4]	00031

CLASS CYCADOPSIDA

Zamiaceae	
Macrozamia communis[1,2,3]	30121 30131 35221 35222 35561 35562 35591

CLASS CONIFEROPSIDA

Araucariaceae	
**Araucaria heterophylla*[1]	92060
Cuppressaceae	
Callitris rhomboidea[1]	10041
Podocarpaceae	
Podocarpus elatus[1,2,3]	05021 05051 30121

CLASS MAGNOLIOPSIDA-LILIIDAE

Amaryllidaceae	
Crinum pedunculatum[1,2,3,4]	00031 05021 05051 10031 40991 40992
Anthericaceae	
Arthropodium minus[1,2]	35591
Sowerbaea juncea[1,2]	60021
Thysanotus juncifolius[1,2]	59051
Tricoryne elatior[1,2]	35601 59051
Araceae	
Alocasia brisbanensis[3]	05051
Gymnostachys anceps[1,2,3,4]	05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35591 35621 52031
Typhonium brownii[1,3]	00031 05051
Arecaceae	
Livistona australis[1,2,3,4]	00031 05021 05051 10031 30021 30041 30061 30071 30121 30131 35041 35221 35222 35561 35562 40051 40052 40981 40982 54041

Asparagaceae	
**Protasparagus aethiopicus*[1]	05021 35041
**Protasparagus plumosus*[1,2]	05021 10031
Asteliaceae	
Cordyline stricta[2]	
Blandfordiaceae	
Blandfordia grandiflora[1,2]	58991 60021
Centrolepidaceae	
Centrolepis fascicularis[2]	
Centrolepis strigosa subsp. *strigosa*[1]	58991
Colchicaceae	
Burchardia umbellata[1,2]	58991 59051 60021
Wurmbea biglandulosa[1]	59051
Commelinaceae	
Aneilema acuminatum[1,3,4]	00031 05051 30021
Commelina cyanea[1,2,4]	05021 00031 10031 10041 30021 30061 30071 35041 35081 35121 35122 35131 35221 35222 35601 35611 35621 40051 40052 40991 40992
**Tradescantia albiflora*[1]	10031 35621
Cyperaceae	
Abildgaardia ovata[1]	63021
Baumea acuta[1]	58991 60021
Baumea arthrophylla[1]	64031
Baumea articulata[1,2]	40031 40032 55062
Baumea juncea[1,2,4]	40051 40052 40991 40992 51022 55062 59051 64021 65031
Baumea muelleri[1]	60021
Baumea rubiginosa[1,2]	55062 65031
Baumea teretifolia[1,2]	64031
Carex appressa[1,2]	00031 30021
Carex breviculmis[1]	35611
Carex brunnea[2]	
Carex pumila[1]	90100
Caustis pentandra[1]	58041 58991
Caustis recurvata var. *recurvata*[1,2]	50022 54021 58041
**Cyperus brevifolius*[2]	
Cyperus enervis[1]	35591 35601
Cyperus flaccidus[2]	
Cyperus laevis[2]	
Cyperus lucidus[2,4]	00031
Cyperus polystachyos[1,2,4]	40991 40992 63021
Cyperus tetraphyllus[1,2]	30061
Cyperus trinervis[1,2]	00031
Fimbristylis dichotoma[1]	63021
Fimbristylis ferruginea[1,2,4]	40051 40052 40991 40992 55062 61021 64021 65021 65031
Gahnia aspera[1,2,3,4]	05051 10031 10041 30061 30111 30131 35131 52031 54041
Gahnia clarkei[1]	30041 35561 35562 40031 40032 40051 40052 40981 40982 51022 54041
Gahnia melanocarpa[1,2]	00031 05051 10041 30021 30061 30071 30111 30121 30131 35611
Gahnia sieberiana[1,2]	60021
Gymnoschoenus sphaerocephalus[1,2]	60021
Isolepis cernua[2]	

Cyperaceae cont.	
Isolepis inundata[1,2]	40981 40982
Isolepis nodosa[1,2,4]	10031 40051 40052 40991 40992 54111 62021 62022 63021
Lepidosperma concavum[1]	54101
Lepidosperma elatius[1,2]	30131 35041 35591
Lepidosperma laterale[1,2]	00031 30111 30121 30131 35041 35121 35122 35131 35591 35601 54041 59051
Lepidosperma neesii[1]	58991 59051 60021 64031
Ptilothrix deusta[1,2]	58991 59051 60021
Schoenoplectus litoralis[1,2]	55062 65021 90200
Schoenus apogon[1]	59051
Schoenus brevifolius[1,2]	51022 58991 60021 64031
Schoenus ericetorum[1,2]	50022 58041
Schoenus lepidosperma subsp. _pachylepis_[1]	58991 60021
Schoenus melanostachys[1,2]	92080
Scleria mackaviensis[1]	35591
Dioscoreaceae	
Dioscorea transversa[1,2,3,4]	05021 05051 10031 10041 30021 30061 30071 30111 30121 30131 35131 35561 35562 52031
Flagellariaceae	
Flagellaria indica[1,2,3]	05021 05051 10031
Geitonoplesiaceae	
Eustrephus latifolius[1,2,4]	10031 30021 30061 30071 30111 30121 30131 35041 35561 35562 35621
Geitonoplesium cymosum[1,2,3,4]	05021 05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35121 35122 35601 35611 35621 52031
Haemodoraceae	
Haemodorum corymbosum[2]	
Iridaceae	
*_Freesia_ hybrid[1]	92060
*_Gladiolus gueinzii_[1]	62021 62022
Patersonia glabrata[1,2]	50022 58041
Patersonia sericea[1,2]	58041
Patersonia sp. aff. _fragilis_[1,2,3]	35561 35562 58991 59051 60021
*_Romulea rosea_ var. _australis_[1]	92060
Juncaceae	
*_Juncus cognatus_[2]	
Juncus kraussii subsp. _australiensis_[1,2,4]	25022 40051 40052 40991 40992 55062 61021 65021 65031
Juncus mollis[2]	
Juncus planifolius[2]	
Juncus usitatus[2]	
Juncaginaceae	
Triglochin procerum s. lat.[1]	64031
Triglochin striatum[1]	61021
Lomandraceae	
Lomandra confertifolia subsp. _pallida_[1]	35131
Lomandra glauca[1]	50022 58041 58991 59051
Lomandra longifolia[1,2,3]	30021 30061 30071 30121 30131 35041 35081 35121 35122 35131 35221 35222 35561 35562 35591 35601 35611 35621 51022 54021 54101 54111 59051 62021 62022 63021

Lomandraceae cont.	
Lomandra multiflora subsp. _multiflora_[1]	30071 30131 35041 35081 35591 59051
Lomandra spicata[1]	05021 05051 30041
Orchidaceae	
Acianthus exsertus[2]	
Caladenia catenata[2]	
Calanthe triplicata[1,3]	05051
Cymbidium suave[2]	
Dendrobium aemulum[3]	05051
Dendrobium gracilicaule[3]	05051
Dendrobium speciosum[3]	05051
Dendrobium tetragonum[1,3]	05021 05051
Dipodium variegatum[1]	35561 35562
Erythrorchis cassythoides[1]	90300
Microtis parviflora[1]	92060
Pterostylis concinna[2]	
Pterostylis nutans[1,2]	35041
Sarcochilus falcatus[3]	05051
Philydraceae	
Philydrum lanuginosum[1,2]	64031
Phormiaceae	
Dianella caerulea[1,2,3,4]	00031 30021 30061 30071 30121 30131 35041 35081 35121 35122 35131 35221 35222 35561 35562 35591 35601 35611 35621 40051 40052 40981 40982 51022 54021 54041 54101
Dianella congesta[1]	54111 62021 62022
Dianella longifolia[1]	40991 40992
Dianella longifolia var. _longifolia_[4]	00031
Dianella revoluta[1]	35041 35591 50022
Stypandra glauca[2]	
Thelionema caespitosum[2]	
Poaceae	
*_Ammophila arenaria_[1]	54111
*_Andropogon virginicus_[1]	35041 51022 64031 92030
Aristida ramosa[1]	35621
Aristida warburgii[1]	59051
*_Axonopus affinis_[1,2]	92030
*_Axonopus compressus_[2]	
*_Briza maxima_[1,2]	92030 92070
*_Briza minor_[1,2]	92070
*_Bromus cartharticus_[1]	92030
Capillipedium parviflorum[1]	35041
Cenchrus caliculatus[2]	
Chloris divaricata var. _divaricata_[2]	
*_Chloris gayana_[1,2]	92030 92070
Cymbopogon refractus[1,2]	35041 35131 35591 63021
Cynodon dactylon[1,2]	35131 92030
Dichelachne micrantha[1]	35041
*_Digitaria ciliaris_[1]	92070
Digitaria didactyla[1]	63021
Digitaria parviflora[1,2]	35041 35591 35611
Echinopogon ovatus[2]	
*_Ehrharta erecta_[1,2]	10031 40051 40052 54101 54111
*_Eleusine indica_[1,2]	92070

Poaceae cont.

Entolasia marginata[1,2]	00031 05021 30021 30071 30131 35041 35121 35122 35131 35221 35222 35601 35621
Entolasia stricta[1,2]	30071 35121 35122 40981 40982 58991
Eragrostis benthamii[2]	
Eragrostis brownii s. lat.[1,2]	35041 58041 59051
**Eragrostis tenuifolia*[1]	92030 92060
Eragrostis trachycarpa[2]	
Eriochloa procera[1,2,4]	40051 40052 40991 40992 64021
Hemarthria uncinata[1,2,4]	40981 40982 40991 40992 51022 64021
Imperata cylindrica var. *major*[1,2,3,4]	00031 30061 30131 35041 35081 35121 35122 35131 35561 35562 35591 35601 35611 35621 40031 40032 50022 51022
Ischaemum australe[1]	40031 40032
Leersia hexandra[2]	
Microlaena stipoides var. *stipoides*[1,2]	90100
Oplismenus aemulus[1,2,4]	00031 05021 05051 35121 35122 35591 35611 35621 40991 40992
Oplismenus imbecillis[1,2]	00031 05051 10031 30021 30041 30061 30111 30121 30131 35041 35081 35591 35601 35611 54041
**Panicum maximum*[2]	
Panicum pygmaeum[1]	10041
Panicum simile[1,2]	50022 58041
Paspalidium aversum[2]	
Paspalidium distans[1]	35041 35131 40981 40982 51022
**Paspalum dilatatum*[1,2]	63021 92030 92070
Paspalum orbiculare[1]	40981 40982
**Paspalum urvillei*[1]	92030 92070
Paspalum vaginatum[1]	90200
**Pennisetum clandestinum*[1,2]	92030
Phragmites australis[1,2,4]	40051 40052 40991 40992 65031
Poa labillardieri[1,2]	30061 30071 30121 30131 35041 35081 35131 35591 35601 35611 35621
Poa poiformis[1]	40051 40052
**Polypogon monspeliensis*[2]	
Sacciolepis indica[1]	40991 40992
**Setaria gracilis*[1,2]	40991 40992
**Setaria pumila*[1,2,4]	40991 40992
Spinifex sericeus[1,2]	54111 62021 62022
**Sporobolus indicus* var. *capensis*[1,2]	35041 35611 63021 92030
Sporobolus virginicus[1,2,4]	25022 40051 40052 40991 40992 61021 63021 64021 65021 91030
**Stenotaphrum secundatum*[1,2]	63021
Themeda australis[1,2]	35041 35081 35121 35122 35561 35562 35591 35601 35611 35621 50022 58041 59051 63021
Thonandia longifolia[2]	
Zoysia macrantha[1,2]	40991 40992 54111 62021 62022 63021

Restionaceae

Baloskion pallens[1,2]	51022 60021 64031
Baloskion tetraphyllum subsp. *meiostachyum*[1,2]	40031 40032 40981 40982 51022
Coleocarya gracilis[1]	50022 58041
Eurychorda complanata[1,2]	64031
Hypolaena fastigiata[1,2]	50022 58041 58991 60021
Leptocarpus tenax[1,2]	51022 58991 60021 64031
Lepyrodia muelleri[1]	64031

Restionaceae cont.	
Lepyrodia scariosa[1]	58991 60021
Lepyrodia species A[1]	64031
Sporadanthus interruptus[1,2]	51022 58991 60021
Ripogonaceae	
Ripogonum album[1,2]	05051
Ripogonum discolor[2,3,4]	05051 10031
Ripogonum fawcettianum[1,2,3,4]	05051 10031 30021 30131
Smilacaceae	
Smilax australis[1,2,3,4]	05021 05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35621 52031
Smilax glyciphylla[1,2,3]	05021 30061 30071 35561 35562 54041
Uvulariaceae	
Tripladenia cunninghamii[1,2]	05021 30021 30121
Xanthorrhoeaceae	
Xanthorrhoea fulva[1,2]	40031 40032 51022 54021 60021
Xanthorrhoea macronema[1,2,3]	30121 30131 35041 35121 35122 35221 35222 35561 35562 35591
Xyridaceae	
Xyris gracilis subsp. *gracilis*[1]	58991
Xyris juncea[2]	
Xyris operculata[1,2]	64031
Zingiberaceae	
Alpinia arundelliana[1]	30021
Alpinia caerulea[1]	05051 30021 30061 30071
Alpinia caerulea s. lat.[2,3]	05051

CLASS MAGNOLIOPSIDA-MAGNOLIIDAE

Acanthaceae	
Pseuderanthemum variabile[1]	00031 05021 05051 10031 30021 30041 30061 30071 30121 30131 35041 35081 35561 35562 35601 35621
Aizoaceae	
Carpobrotus glaucescens[1,2,4]	54101 54111 62021 62022 63021
Macarthuria neocambrica[1]	58041
Sesuvium portulacastrum[1,2,4]	64021
Tetragonia tetragonoides[1,2,4]	62021 62022
Alangiaceae	
Alangium villosum subsp. *polyosmoides*[1,2,3]	05051 10031
Amaranthaceae	
Alternanthera denticulata[1,2,4]	40051 40052 40991 40992
Deeringia amaranthoides[1,2]	05051
Anacardiaceae	
Euroschinus falcata var. *falcata*[1,2,3,4]	05051 10031 30021 30111 30121
Apiaceae	
Actinotus helianthi[1,2]	50022 54021 58041
Apium prostratum subsp. *prostratum*[1,2]	40051 40052 40991 40992 65031 91030
Centella asiatica[1,2]	35081 35621 63021
*_Ciclospermum leptophyllum_[2]	
Daucus glochidiatus[2]	
Hydrocotyle acutiloba[1,2]	35611
*_Hydrocotyle bonariensis_[1,2]	54111 62021 62022 90100
Hydrocotyle geraniifolia[1]	30061

Apiaceae cont.	
Hydrocotyle peduncularis[1]	00031 30131 35041 35081 35591
Hydrocotyle verticillata[2]	
Platysace ericoides[1,2]	50022 58041 59051
Platysace lanceolata[1,2]	50022 51022 58041 58991 60021
Trachymene incisa subsp. _incisa_[1,2]	35561 35562 58041
Xanthosia pilosa[1,2]	35561 35562 50022 54021 54101 58041 59051 60021
Xanthosia tridentata[1]	59051
Apocynaceae	
Melodinus australis[2]	
Parsonsia induplicata[1]	30111
Parsonsia straminea[1,2,3,4]	05021 05051 10031 10041 30041 30111 30131 40051 40052 52031 54041
Parsonsia velutina[2,3]	05051
Araliaceae	
Astrotricha longifolia[1,2]	30061
Polyscias elegans[1,2,3,4]	00031 05021 05051 10031 30111 35221 35222 35591
Polyscias sambucifolia[1,2]	35041 35561 35562
Asclepiadaceae	
Cynanchum carnosum[1,2,4]	40051 40052 40991 40992 65021
Cynanchum elegans[1]	30111
*_Gomphocarpus fruticosus_[1,2]	35121 35122 35591 35611 35621 40991 40992
Marsdenia flavescens[2,4]	10031
Marsdenia rostrata[1,2]	10031 35041 35221 35222 35561 35562
Marsdenia lloydii[2]	
Tylophora paniculata[1]	30041 30121 30131 52031
Asteraceae	
*_Ageratina adenophora_[1,2,4]	00031 35611 92030
*_Ageratina riparia_[1]	92070
*_Arctotheca calendula_[1]	92060
*_Arctotheca populifolia_[1]	62021 62022
*_Aster subulatus_[1]	40991 40992 64021 65031 92030
*_Baccharis halimifolia_[1]	40051 40052 65031
*_Bidens pilosa_[1]	92030
*_Bidens tripartita_[2]	
Brachycome angustifolia var. _heterophylla_[2]	
Cassinia aculeata[1]	54101
Cassinia uncata[1,2]	90100
Centratherum punctatum subsp. _australianum_[1]	35601
*_Chrysanthemoides monilifera_ subsp. _rotundata_[1,2]	30021 30061 30071 35041 35081 35121 35122 35131 35561 35562 35601 35611 35621 40051 40052 40991 40992 54041 54101 54111 59051 62021 62022 63021
*_Cirsium vulgare_[1,2]	40051 40052 92070
*_Conyza albida_[1]	40051 40052 40991 40992 92030
*_Conyza bilbaoana_[1]	54111 62021 62022
*_Conyza bonariensis_[2]	
*_Conyza canadensis_ var. _canadensis_[2,4]	40991 40992
*_Conyza parva_[1]	40031 40032
*_Cotula coronopifolia_[1,2]	40051 40052
Craspedia variabilis[1,2]	59051
*_Delairea odorata_[1,2]	05021 40051 40052
Eclipta platyglossa[1,2]	40991 40992

Asteraceae cont.	
Enydra fluctuans[2]	
Epaltes australis[2]	
**Erechtites valerianifolia*[2]	
**Gazania rigens*[1]	92070
Gnaphalium sphaericum[1]	35591
Helichrysum scorpioides[1,2]	59051
**Hypochaeris glabra*[1,2]	92060
**Hypochaeris radicata*[1,2]	40991 40992 63021 92030
**Lactuca serriola*[2]	
Lagenifera gracilis[1]	35041 59051
Leptinella longipes[2,4]	90200
Melanthera biflora[1,2]	9130
Olearia nernstii[1,2,3]	30061 35131 35561 35562
Ozothamnus diosmifolius[1,2]	35121 35122 92030
Pseudognaphalium luteoalbum[1,2]	40991 40992
Senecio hispidulus var. *dissectus*[2]	
Senecio hispidulus var. *hispidulus*[1,2]	35121 35122 35621 40991 40992
Senecio lautus subsp. *maritimus*[1]	62021 62022 63021 91030
Senecio linearifolius[1]	05051
**Senecio madagascariensis*[1,2]	40991 40992 92030 54101
Senecio vagus[1]	30021
**Senecio vulgaris*[2]	
Sigesbeckia orientalis subsp. *orientalis*[1,2]	35121 35122 35591 35621
**Soliva anthemifolia*[2]	
**Sonchus asper* subsp. *glaucescens*[1]	40051 40052 40991 40992
**Sonchus oleraceus*[1,2]	10031 63021
**Tagetes minuta*[1]	92070
Vernonia cinerea var. *cinerea*[1,2]	35041 35081 35621 65031
**Xanthium italicum*[1]	92070
Avicenniaceae	
Avicennia marina subsp. *australasica*[1,2,4]	25022
Basellaceae	
**Anredera cordifolia*[1,2]	10031
Baueraceae	
Bauera capitata[1,2]	60021
Bignoniaceae	
Pandorea pandorana[1,2,3]	05021 05051 10031 10041 30041 30111 30121 30131 35221 35222 50022 54101
Brassicaceae	
**Cakile edentula*[2]	
**Cakile maritima*[1]	62021 62022
Buddlejaceae	
**Buddleja madagascariensis*[1]	40051 40052
Campanulaceae	
Wahlenbergia communis[2]	
Wahlenbergia stricta[1]	35041
Capparaceae	
Capparis arborea[1,2,3,4]	05021 05051 10031 10041 30111
Caprifoliaceae	
**Lonicera japonica*[1]	35621

Caryophyllaceae	
*_Petrorhagia velutina_[1]	92070
*_Spergularia marina_[1]	40051 40052
Stellaria flaccida[2]	
Casuarinaceae	
Allocasuarina defungens[1]	58991
Allocasuarina littoralis[1,2]	35081 35131 35591 59051
Allocasuarina simulans[1,2]	58041
Allocasuarina torulosa[1,2,3]	30131 35041 35121 35122 35591 35601
*_Casuarina equisetifolia_ subsp. _incana_[1,2]	90100
Casuarina glauca[1,2,4]	00031 10031 30111 35121 35122 40031 40032 40051 40052 40991 40992 54041 55062 61021 63021 64021 65021 65031
Celastraceae	
Cassine australis var. _australis_[1,2,3,4]	05021 05051 10031 10041 30111 30121 30131 52031
Celastrus australis[1,2,4]	10031
Celastrus subspicata[1,2]	30071 30111 35041
Chenopodiaceae	
Atriplex australasica[2,4]	40991 40992
*_Atriplex prostrata_[1]	40051 40052
Chenopodium glaucum[1,2]	40051 40052
Enchylaena tomentosa[1]	91030
Einadia hastata[1,2]	54111
Einadia nutans[2]	
Einadia nutans subsp. _linifolia_[1]	91030
Rhagodia candolleana subsp. _candolleana_[2]	10031
Sarcocornia quinqueflora subsp. _quinqueflora_[1,2,4]	25022 61021 64021 65021
Suaeda australis[1,2,4]	40051 40052
Chloanthaceae	
Chloanthes stoechadis[1,2]	50022 54021 58041
Clusiaceae	
Hypericum gramineum[1]	35041 59051
Convolvulaceae	
Calystegia marginata[1]	00031
Calystegia soldanella[1]	62021 62022
Dichondra repens[1,2]	30071 30111 30121 35081 35121 35122 35131 35591 35601 35621 63021
*_Ipomoea cairica_[1,2,4]	10031 40051 40052 40991 40992 54111 65021
Ipomoea pes-caprae subsp. _brasiliensis_[1]	62021 62022
Polymeria calycina[1,2]	35041 63021
Crassulaceae	
Crassula sieberiana[1]	91030
Cunoniaceae	
Aphanopetalum resinosum[1,2,3,4]	05051 10031
Schizomeria ovata[1,2]	30021
Dilleniaceae	
Adrastaea salicifolia[1,2]	60021
Hibbertia aspera[1,2]	35041 35081 35221 35222 35561 35562
Hibbertia dentata[1,2]	30021 30061 30071 30121 30131 35221 35222 35561 35562 35601 35611 40031 40032 40981 40982 59051
Hibbertia diffusa[1,2]	54021
Hibbertia empetrifolia[1]	59051

Dilleniaceae cont.	
Hibbertia fasciculata[1,2]	54021 58041 58991 60021
Hibbertia linearis[1,2]	50022 54021 58041
Hibbertia obtusifolia[1,2,3]	35561 35562 54101
Hibbertia riparia s. lat.[1,2]	58991
Hibbertia rufa s. lat.[1]	54021
Hibbertia scandens[1,2,4]	00031 10041 35041 35081 35131 35221 35222 35561 35562 35591 35611 35621 54101 63021
Droseraceae	
Drosera auriculata[1,2]	60021
Drosera peltata[1]	58991 59051 60021
Drosera pygmaea[1]	58991
Drosera spatulata[1,2]	64031
Ebenaceae	
Diospyros australis[1,2,3,4]	05021 05051 10031 10041 30041 30111 30121 30131 35591 52031
Diospyros pentamera[1,2,3,4]	05021 05051 10031 30071 30111 30121 30131 52031
Elaeocarpaceae	
Elaeocarpus obovatus[1,2,3]	00031 05021 05051 10031 30061
Elaeocarpus reticulatus[1,2]	05021
Epacridaceae	
Astroloma pinifolium[1,2]	54101
Brachyloma daphnoides[1]	50022 58041
Epacris microphylla var. *microphylla*[2]	
Epacris obtusifolia[1,2]	60021
Epacris pulchella[1,2]	58991 59051
Leucopogon ericoides[1,2]	50022 54021
Leucopogon juniperinus[1,2]	35041
Leucopogon lanceolatus var. *gracilis*[1,2]	40981 40982
Leucopogon lanceolatus var. *lanceolatus*[2]	
Leucopogon leptospermoides[1]	54021 58991
Leucopogon parviflorus[1,2]	40991 40992 62021 62022
Leucopogon virgatus[1,2]	58041 58991
Monotoca elliptica[1,2]	30131 35561 35562 54101
Monotoca scoparia[1,2]	50022 54021 58041 58991 59051
Sprengelia incarnata[1,2]	60021
Sprengelia sprengelioides[1]	60021
Styphelia viridis[2]	
Trochocarpa laurina[1,2]	05021 30021 30061 30071 30121 30131 35081
Woollsia pungens[1,2]	54021
Escalloniaceae	
Abrophyllum ornans[2]	
Euphorbiaceae	
Actephila lindleyi[1,2,3]	05051
Alchornea ilicifolia[1,2,3]	05021 05051 10031
Amperea xiphoclada[1,2]	50022 54021 58041
Baloghia inophylla[1,2,3]	05021 05051 30041
Breynia oblongifolia[1,2,3,4]	00031 05021 10041 30021 30041 30061 30071 30111 30121 30131 35041 35131 35221 35222 35561 35562 35591 35611 52031 54101
Chamaesyce psammogeton[1]	62021 62022
Claoxylon australe[1,2,3,4]	05051 10031 30021 30041 30071
Cleistanthus cunninghamii[1,2,3]	05051

Euphorbiaceae cont.	
Croton insularis[1,2,3]	05051 90300
Croton verreauxii[1,2]	30071
Drypetes deplanchei[1,2,3,4]	05021 05051 10031 10041 30021 30041 30071 30111 52031
Glochidion ferdinandi var. *ferdinandi*[1,2,3,4]	00031 05021 05051 10031 10041 30041 35041 35561 35562
Mallotus philippensis[1,2,3,4]	05051 10031 30021 30071 30111
Omalanthus nutans[1,2]	40051 40052
Phyllanthus gunnii[1,2]	30071 30131
Poranthera corymbosa[1]	90100
Poranthera microphylla[1,2]	35041
Pseudanthus orientalis[1,2]	58991
Ricinocarpus pinifolius[1,2]	50022 58041 58991
Eupomatiaceae	
Eupomatia laurina[1,2]	05051 30021 30061
Fabaceae-Caesalpinioideae	
Senna acclinis[5]	
**Senna X floribunda*[1,2,3]	05021 92030
**Senna pendula* var. *glabrata*[1,2,3]	00031 05051 35081 35131 40051 40052
Fabaceae-Faboideae	
Aotus ericoides[1,2]	54021 58991
Aotus lanigera[2]	
Austrosteenisia blackii var. *blackii*[1]	10031
Bossiaea ensata[1,2]	50022 58041
Bossiaea heterophylla[1,2]	35561 35562 50022 54021 54101 58041
Bossiaea prostrata[1,2]	59051
Canavalia rosea[1,2]	63021 91030
Chorizema parviflorum[2]	
**Crotalaria semperflorens*[1]	92070
Daviesia ulicifolia[1]	35041 35561 35562
Desmodium brachypodum[1,2]	30131 35081 35121 35122 35591 35601 35621 40031 40032
Desmodium nemorosum[1,2]	35221 35222
Desmodium rhytidophyllum[1,2]	35041 35081 35131 35561 35562 35591 35601 35621
Desmodium varians[1,2]	30061 30071 30121 30131 35041 35081 35121 35122 35561 35562 35591 35601 35611 35621
Dillwynia floribunda var. *floribunda*[1,2]	58991 60021
Dillwynia glaberrima[1,2]	58041
Dillwynia retorta[1,2]	35561 35562 50022 54021 58041
**Erythrina X sykesii*[1,2]	92060
Galactia species A[1]	63021
Glycine clandestina s. lat.[1,2]	30061 35621
Glycine microphylla[1]	30131 35041 35081 35121 35122 35131 35561 35562 35591
Glycine tabacina s. lat.[1,2]	35121 35122 35601
Gompholobium glabratum[1]	58041
Gompholobium latifolium[1,2]	35221 35222 35561 35562
Gompholobium pinnatum[1]	60021
Gompholobium virgatum var. *virgatum*[1,2]	50022 58041
Hardenbergia violacea[1,2]	30131 35041 35081 35131 35561 35562 35591 35601 35611 35621 50022 58041
Indigofera australis[1,2]	35591
Jacksonia scoparia[1]	35041
Kennedia prostrata[2]	

Fabaceae-Faboideae cont.	
Kennedia rubicunda[1,2,4]	00031 30041 30071 35041 35121 35122 35561 35562 35621 40981 40982 51022
Mirbelia rubiifolia[2]	
Oxylobium ilicifolium[1,2]	35041 35591
Phyllota phylicoides[1,2]	50022 54021 58041
Platylobium formosum[1,2,3]	35041 35561 35562
Pultenaea blakelyi[1,2]	30061 40981 40982
Pultenaea retusa[1,2]	35041 59051
Pultenaea villosa[1,2]	35041
Sphaerolobium vimineum[1]	59051
**Trifolium repens*[1,2]	92070
**Vicia sativa*[1]	92070
Viminaria juncea[1,2]	40991 40992 64031
Fabaceae-Mimosoideae	
Acacia baueri subsp. *baueri*[1]	58991
Acacia binervata[1,2]	30041 30061 35041
Acacia brownii[1]	59051
Acacia elongata[1,2]	40981 40982
Acacia falcata[1,2]	35041
Acacia floribunda[3]	35591
Acacia irrorata subsp. *irrorata*[1,2]	10041 35561 35562 92030
Acacia longifolia[1,2,3,4]	00031 10041 35041 35561 35562 35621 40051 40052 40981 40982 40991 40992 54021
Acacia maidenii[1,2,3,4]	00031 05021 05051 10031 10041 30021 30061 30071 30111 30121 30131 35041 35081 35121 35122 35131 35221 35222 35591 35601 35611 35621 52031 92030
Acacia melanoxylon[1,2]	10041
Acacia myrtifolia[1,2]	35041 59051
Acacia quadrilateralis[1]	58041
**Acacia saligna*[1]	54111
Acacia sophorae[1,2,4]	00031 54101 54111 59051 60021 62021 62022 63021
Acacia stricta[1,2]	35041 35591
Acacia suaveolens[1,2]	35561 35562 50022 54021 58041
Acacia terminalis[1,2]	35561 35562
Acacia ulicifolia[1,2]	35041 35081 35561 35562 50022 54021 58041
Pararchidendron pruinosum var. *pruinosum*[1,2,3,4]	05051 10031 35591
Flacourtiaceae	
Scolopia braunii[1,2,3,4]	05021 05051 10031 30111
Fumariaceae	
**Fumaria capreolata* subsp. *capreolata*[2]	
Gentianaceae	
Centaurium spicatum[1]	40991 40992 64021
**Centaurium tenuiflorum*[2]	
Geraniaceae	
Geranium homeanum[1]	00031 30061 30071 35041 35081 35611
Geranium solanderi var. *solanderi*[1,2]	35591 35621
Goodeniaceae	
Dampiera stricta[1,2]	50022 51022 58041 58991 59051
Goodenia heterophylla subsp. *eglandulosa*[1,2]	35041
Goodenia ovata[1,2]	40051 40052
Goodenia paniculata[1,2]	59051 63021 64021
Goodenia stelligera[1,2]	60021 64031
Scaevola calendulacea[1,2]	54111 62021 62022 90100

Gyrostemonaceae	
Codonocarpus attenuatus[2]	
Haloragaceae	
Gonocarpus micranthus[1,2]	58991
Gonocarpus tetragynus[1,3]	35041 35131 35561 35562 35601 59051
Gonocarpus teucrioides[1,2]	35561 35562 50022 51022 54101 58041
Lamiaceae	
Mentha diemenica[1]	35561 35562 35601
Mentha satureioides[2]	
Plectranthus parviflorus[1,2,4]	10031 35081 35121 35122 35591 35621
Westringia fruticosa[1,2]	54041 59051 63021 91030
Lauraceae	
Beilschmiedia elliptica[1,2,3]	05051
Cassytha filiformis[1,2]	58041 63021
Cassytha glabella forma *glabella*[1,2]	40991 40992 54021 58991 59051 60021
Cassytha pubescens[1,2]	54101
Cinnamomum oliveri[2]	
Cryptocarya glaucescens[1]	05021 30041
Cryptocarya microneura[1]	30021 30061 30071 30131 35561 35562
Cryptocarya obovata[1,2,3]	05051
Cryptocarya rigida[1,2]	05021 05051 30021 30061 30071 30121 35561 35562
Endiandra discolor[1,2]	05051 10041 30111
Endiandra sieberi[1,2,3]	05021 35561 35562
Litsea reticulata[1,2,3,4]	00031 05021 10031 35591
Neolitsea dealbata[1,2,3]	05051
Lentibulariaceae	
Utricularia dichotoma[1]	35561
Lobeliaceae	
Lobelia alata[1,2]	40991 40992 63021 64021 91030
Pratia purpurascens[1,2]	30061 30071 30121 30131 35041 35081 35121 35122 35131 35591 35601 35611 35621 54041
Loganiaceae	
Logania albiflora[1,2]	35041 54041 63021
Mitrasacme paludosa[2]	
Mitrasacme polymorpha[1,2]	58041 60021
Loranthaceae	
Amyema congener subsp. *congener*[1,2]	30111
Amyema congener subsp. *rotundifolia*[2]	
Dendrophthoe vitellina[1]	35561 35562
Muellerina eucalyptoides[1]	30121 35591
Malvaceae	
Hibiscus heterophyllus subsp. *heterophyllus*[2,3]	05051
Hibiscus trionum[2]	
**Modiola caroliniana*[1]	92060
**Sida rhombifolia*[1,2,4]	35611 40991 40992 92030 92060
Meliaceae	
Dysoxylum fraserianum[1,2,3]	05021 05051 10031
Melia azedarach[2]	
Synoum glandulosum[1,2]	00031 05051 10031 30021 30041 30061 30071 30111 30121 35561 35562 40051 40052 54041

Menispermaceae	
Legnephora moorei[1,2]	10041
Sarcopetalum harveyanum[1,2,3]	05021 10031 30061 35041 54111
Stephania japonica var. *discolor*[1,2,3,4]	00031 05021 05051 10041 30021 30061 30071 35041 35121 35122 35221 35222 35561 35562 35621 54041
Menyanthaceae	
Villarsia exaltata[1,2]	64031
Monimiaceae	
Daphnandra micrantha[1,3]	05051
Wilkiea huegeliana[1,2,3,4]	05021 05051 10031 30021 30041 35041 40051 40052 52031 54041
Moraceae	
Ficus coronata[1,2,3]	00031 05051 35041
Ficus fraseri[1,2,3,4]	00031 05021 10031 30111
Ficus obliqua[2,3]	05051
Ficus rubiginosa[1,2,3,4]	05051 10031 10041
Ficus superba var. *henneana*[1,2,3]	05051 10031 52031
Ficus watkinsiana[1,2,3]	05021 05051 10031 30041
Maclura cochinchinensis[1,2,3,4]	00031 05021 10031 92030
Malaisia scandens subsp. *scandens*[1,2,3,4]	05021 05051 10031
Streblus brunonianus[1,2,3,4]	05051 10031 30111 30121
Myoporaceae	
Myoporum acuminatum s. str.[1,2,4]	00031 10031 40051 40052 40991 40992
Myoporum boninense subsp. *australe*[1,2]	63021
Myrsinaceae	
Aegiceras corniculatum[1,2]	25022 40051 40052
Embelia australiana[1,2,3,4]	05021 05051 10031 10041 30021 30041 30071 30111 30121
Rapanea howittiana[1]	05021
Rapanea variabilis[1,2,3,4]	05021 05051 10031 10041 30021 30061 30111 30121 30131 35041 52031
Myrtaceae	
Acmena smithii[1,2,3,4]	00031 05021 05051 10031 30021 30131 54041
Angophora costata[1,2,3]	35041 35221 35222 35561 35562 50022 59051
Angophora floribunda[1,2]	35081 35131 35601 35611
Austromyrtus acmenoides[2,3]	05051
Austromyrtus bidwillii[1,2,3,4]	05021 05051 10031
Backhousia myrtifolia[1,2]	05051
Baeckea diosmifolia[1]	58991
Baeckea imbricata[1,2]	58991
Callistemon citrinus[1,2]	60021
Callistemon pachyphyllus[1,2]	51022 60021 64031
Callistemon salignus[1,2,4]	00031 40991 40992 30111 30121 35561 35562
Calytrix tetragona[1,2]	58041
Choricarpia leptopetala[1]	10041 30111 52031
Corymbia intermedia[1]	30041 35041 35601 35621
Corymbia maculata[1,2,3]	30131 35041 35591 35621
Darwinia leptantha[1,2]	58991 60021
Eucalyptus acmenoides[1,2,3]	30121 30131 35591
Eucalyptus carnea[1]	35041 35081
Eucalyptus fergusonii subsp. *fergusonii*[1,2,3]	30121 30131 35591
Eucalyptus grandis[1,2]	30041 30061 35601
Eucalyptus microcorys[1,2]	30021 30041 30061 30071 35041 35081 35121 35122 35601 35611

Myrtaceae cont.	
Eucalyptus pilularis[1,2,3]	30041 30061 35041 35081 35121 35122 35221 35222 35561 35562 50022
Eucalyptus propinqua[1,2]	30061 35041 35121 35122
Eucalyptus resinifera subsp. *hemilampra*[1]	35041 35081
Eucalyptus robusta[1,2]	00031 40031 40032 40981 40982 51022 54021 64031
Eucalyptus tereticornis[1,2]	30111 35041 35081 35121 35122 35131 35601
Leptospermum juniperinum[1,2]	58991 59051 60021 64031
Leptospermum laevigatum[1,2]	54101 58041
Leptospermum liversidgei[1,2]	58991 60021
Leptospermum polygalifolium[1,2]	40031 40032 40981 40982 51022 54021 58991 59051
Leptospermum semibaccatum[1]	58991
Leptospermum trinervium[1,2]	40981 40982 50022 54021 58041 58991
Lophostemon confertus[1,2]	00031 10041 30021 30041 30061 30071 35041
Melaleuca armillaris[1,2]	54041
Melaleuca ericifolia[1,2]	40031 40032 40991 40992
Melaleuca linariifolia[1,2]	40981 40982
Melaleuca nodosa[1,2]	51022 54021 58991 60021
Melaleuca quinquenervia[1,2,4]	00031 30041 40031 40032 40051 40052 40981 40982 40991 40992 51022 54041 55062 59051 60021 64021 64031
Melaleuca sieberi[1,2]	51022 60021
Melaleuca thymifolia[1,2]	51022 59051 64031
Ochrosperma lineare[1,2]	54021
Rhodamnia rubescens[1,2,3]	05051 30021 30061 30071
Rhodomyrtus psidioides[1,2,3,4]	00031 05021
Syncarpia glomulifera[1,2]	35041
Syzygium australe[2,3]	05051
Syzygium francisii[2,3]	05051
Syzygium oleosum[1,2,3]	05021 05051 40051 40052
Tristaniopsis laurina[2,3]	05051
Nyctaginaceae	
Pisonia umbellifera[1,2,3]	05051
Olacaceae	
Olax stricta[1,2]	51022 58041
Oleaceae	
Jasminum volubile[1,2,3,4]	05021 05051 10031 30111 35591 52031
Notelaea longifolia forma *intermedia*[1,2,3,4]	00031 05021 05051 10031 10041 30021 30041 30061 30071 30111 30121 30131 35081 35221 35222 35561 35562 35591 52031
Olea paniculata[1,2,3,4]	00031 05021 05051 10031 30111 30121 35591
Onagraceae	
**Oenothera affinis*[2]	
**Oenothera mollissima*[1]	92070
Oxalidaceae	
Oxalis chnoodes[1]	30071 30121 35591
Oxalis exilis[1]	35611
Oxalis rubens[1]	62021 62022
Passifloraceae	
**Passiflora edulis*[1,2]	30021 35041
Passiflora herbertiana subsp. *herbertiana*[1,2]	30071 35601 35611
**Passiflora subpeltata*[1,2,3,4]	00031 05051 10031 10041 30021 30061 30071 30121 35081 35121 35122 35131 35611 35621 92030

Peperomiaceae	
Peperomia blanda var. *floribunda*[2,3,4]	05051 10031
Phytolaccaceae	
Monococcus echinophorus[2,4]	10031
**Phytolacca octandra*[2]	
Pittosporaceae	
Billardiera scandens[1,2]	35041 59051
Citriobatus pauciflorus[1,2,3,4]	05021 05051 10031 30021 30041 30061 30071 30111 30121 35591
Hymenosporum flavum[1,2,3]	05051 30021 30041 30061
Pittosporum revolutum[1,2,3,4]	00031 05021 10031 10041 30041 30111 52031
Pittosporum undulatum[1,2,3]	05051 10031 10041 30111 30121 30131 35041 35591 40051 40052 52031
Plantaginaceae	
Plantago debilis[1]	35591 35621 54041 63021
**Plantago major*[2]	
**Plantago lanceolata*[1,2]	92030 92060
Polygalaceae	
Comesperma ericinum[1,2]	58041
Polygonaceae	
Muehlenbeckia gracillima[2]	
Persicaria decipiens[2]	
Rumex brownii[2]	
**Rumex crispus*[2]	
Portulacaceae	
Portulaca oleracea[1,2]	91030
Primulaceae	
**Anagallis arvensis*[1,2]	63021
Samolus repens[1,2]	40991 40992 61021 64021 65021
Proteaceae	
Banksia aemula[1,2]	50022 51022 54021 58041 58991 60021
Banksia ericifolia var. *macrantha*[1,2]	58991 60021
Banksia integrifolia subsp. *integrifolia*[1,2,3]	05021 05051 35561 35562 35611 54101 54111 59051 63021
Banksia oblongifolia[1]	51022 54021 58991 60021
Banksia robur[1,2]	60021
Banksia serrata[1,2]	35221 35222 35561 35562 54101
Banksia spinulosa var. *collina*[1,2]	59051
Conospermum taxifolium[1,2]	58041 58991 60021
Hakea sericea[1,2]	35041
Hakea teretifolia[1,2]	59051 60021 64031
Isopogon anemonifolius[1,2]	50022 58041 58991 59051
Lomatia silaifolia[1,2]	35041
Persoonia katerae[1]	35561 35562
Persoonia lanceolata[1,2]	35561 35562 54101 59051
Persoonia levis[1,2,3]	35561 35562 59051
Persoonia linearis[1,2]	35041 35561 35562 63021
Petrophile pulchella[1,2]	58041
Stenocarpus salignus[1,2,3]	05051
Ranunculaceae	
Clematis aristata[1,2]	05051 30021 35561 35562 35621
Clematis glycinoides[1,2,4]	10031 30111 35591
Ranunculus inundatus[2]	
Ranunculus lappaceus[1,2]	35121 35122

Rhamnaceae	
Alphitonia excelsa[1,2,3,4]	00031 05021 05051 10031 10041 30111 35591 40051 40052
Cryptandra amara[1,2]	59051
Cryptandra ericoides[1]	60021
Emmenosperma alphitonioides[2]	
Pomaderris lanigera[1]	10041 35131
Rosaceae	
*_Rubus fruticosus_ spp. aggr.[1,4]	00031 92030
Rubus moluccanus var. _trilobus_[1,2]	00031 30021 35041 35121 35122 35611
Rubus nebulosus[2]	
Rubus parvifolius[1,2]	30061 35081 35121 35122 35621
Rubus rosifolius[1]	00031 35611
Rubiaceae	
Canthium coprosmoides[1,2,3]	05021 05051 10041 30071 30111 30121 52031
*_Coprosma repens_[1]	92060
Durringtonia paludosa[1]	40031 40032 40981 40982
Galium binifolium[1,2]	30061
Galium ciliare[1]	35591
Galium propinquum[1]	35041
Ixora beckleri[1,2,3]	05051
Morinda acutifolia[4]	10031
Morinda jasminoides[1,2]	05021 05051 10041 30021 30041 30061 30131 52031
Opercularia aspera[1,2]	51022 54101
Opercularia diphylla[1]	35041 35591
Opercularia hispida[2]	
Opercularia varia[1]	50022 51022 58041
Pomax umbellata[1,2]	35561 35562 40031 40032 50022 58041
Psychotria loniceroides[1,2]	30021 30061 30071 30121 30131 52031
Randia benthamiana[2,3]	05051
Rutaceae	
Acronychia oblongifolia[1,2,4]	00031 10031 30021 30041
Acronychia wilcoxiana[1,2,3,4]	05021 05051 10031 30111
Boronia falcifolia[1,2]	58991 60021
Boronia parviflora[1,2]	60021
Boronia pinnata[1,2]	54021 58991
Boronia polygalifolia[1,2]	59051
*_Citrus limonia_ s. lat.[1]	92030
Correa reflexa var. _reflexa_[1,2,3]	35561 35562 54101 58041
Eriostemon australasius subsp. _australasius_[1,2]	35561 35562 50022 58041
Geijera latifolia[1,2,3]	00031 05051
Phebalium squameum subsp. _squameum_[1,2]	35561 35562
Philotheca salsolifolia[2]	
Sarcomelicope simplicifolia subsp. _simplicifolia_[1,2,3,4]	05051 10031 30111 30131
Zieria laxiflora[1,2]	50022 54021
Zieria smithii[1,2]	30061 30071 30111 35041 35561 35562
Santalaceae	
Exocarpos cupressiformis[1,2,4]	00031 30111 35041 40991 40992
Leptomeria acida[2]	
Sapindaceae	
Alectryon coriaceus[1,2,3,4]	05021 05051 10031
Alectryon subcinereus[1,2,4]	05051 10031 30111 52031
Arytera divaricata[1,2,3,4]	05021 05051 10031

Sapindaceae cont.	
Cupaniopsis anacardioides[1,2,3,4]	00031 05021 05051 10031 30021 30041 30061 30071 30111 30121 30131 35221 35222 40991 40992
Dodonaea triquetra[1,2]	30061 30071 30131 35041 35561 35562 35621 54101
Elattostachys nervosa[1,2,3,4]	05051 10031 30111
Guioa semiglauca[1,2,3]	00031 05021 05051 10031 10041 30041 30061 30071 30111 30121 30131 40051 40052
Jagera pseudorhus var. *pseudorhus* forma *pseudorhus*[1]	05021
Mischocarpus pyriformis subsp. *pyriformis*[1,2,3,4]	05051 10031
Rhysotoechia bifoliolata[1,2,3,4]	05051 10031
Sapotaceae	
Planchonella australis[1,2,3,4]	05021 05051 10031 30021 30111 30121
Planchonella myrsinoides[1,2,3]	05051 10031
Scrophulariaceae	
Bacopa monnieri[1,2]	40991 40992 55062 91030
Euphrasia collina[1,2]	58041
Mimulus repens[2]	
Solanaceae	
Duboisia myoporoides[2,3]	05051
**Physalis peruviana*[2]	
Solanum americanum[2]	
**Solanum linnaeanum*[2]	
**Solanum mauritianum*[1,2,4]	10031 40051 40052 92070
**Solanum nigrum*[1,2,4]	00031 30071
Solanum prinophyllum[1,2]	35121 35122
Solanum pungetium[2]	
Solanum stelligerum[1,2]	30021 30061 35121 35122
Solanum vescum[2]	
Stackhousiaceae	
Stackhousia nuda[2]	
Sterculiaceae	
Commersonia fraseri[1,2,3]	00031 05051 10031 30021 30071
Heritiera actinophylla[1,2,3]	05051
Keraudrenia hillii var. *hillii*[2]	
Stylidiaceae	
Stylidium graminifolium[1,2]	58991 60021
Symplocaceae	
Symplocos thwaitesii[2,3]	05051
Thymelaeaceae	
Pimelea linifolia[1,2]	35041 35561 35562 50022 58041 58991 59051 60021 63021
Wikstroemia indica[1,2]	10031 40051 40052
Tropaeolaceae	
**Tropaeolum majus*[2]	
Tremandraceae	
Tetratheca ericifolia[2]	
Tetratheca thymifolia[1,2]	59051
Ulmaceae	
Celtis paniculata[1,2,3]	05021 05051 10031
Trema aspera[1]	05051 10031 10041 30041 30071 35131 35611

Urticaceae	
Dendrocnide photinophylla[1,2,3,4]	05051 10031 30111
Parietaria debilis[2]	
Verbenaceae	
Clerodendrum tomentosum[1,2,3,4]	05021 10031 10041 30021 30041 30111 30131 52031
Gmelina leichhardtii[1,2]	05051
**Lantana camara*[1,2,3,4]	00031 05021 05051 10031 10041 30041 30061 30071 30111 30121 30131 35121 35122 35131 35221 35222 35561 35562 35591 35601 35611 35621 40051 40052 54041 54101 54111
**Verbena incompta*[1,2]	92030
**Verbena rigida*[1]	92030
Violaceae	
Hybanthus monopetalus[2]	
Viola betonicifolia[1,2]	35041
Viola hederacea[1,2,4]	00031 05021 30121 35081 35221 35222 35601 35611 35621 54041 63021
Viscaceae	
Notothixos cornifolius[1]	05051
Vitaceae	
Cayratia clematidea[1,2,3,4]	00031 05021 05051 10031 10041 30021 30041 30061 30071 30111 35121 35122 35591 35601 35611 35621 40051 40052 54041
Cissus antarctica[1,2,3,4]	00031 05021 05051 10031 10041 30021 30061 30071 30111 30121 40031 40032
Cissus hypoglauca[1,2]	00031 05051 10041 30021 30041 30061 30071
Tetrastigma nitens[1,2,3,4]	05051 10031 30021 30041 30111

Vegetation, soils and management of 'Zara': a sandhill remnant on the Riverine Plain

M.J. Stafford and D.J. Eldridge

Stafford, M.J.[1,3] *and Eldridge, D.J*[2]. *([1]School of Geography, University of NSW, Australia 2052. [2]Department of Land and Water Conservation, Centre for Natural Resources, c/- School of Geography, University of NSW, Australia 2052. [3]Current address: Australian Water Technologies, 51 Hermitage Rd, West Ryde, NSW, 2114, Australia) 2000. Vegetation, soils and management of 'Zara': a sandhill remnant on the Riverine Plain. Cunninghamia 6(3): 717–746.* The 'Zara' exclosure (approximately 35°10'21"S, 144°41'59"E) is on a source-bordering dune on the Riverine Plain north of Deniliquin. The vegetation of this sandhill closely represents the original vegetation that once covered sandhills of the south-west Riverina prior to European occupation. Three vegetation communities comprising six associated Map Units were defined by cluster analysis within the 60 ha exclosure. These were the Callitris Mixed Woodland (Map Units 1, 2, 3, and 6), the Black Box Woodland (Map Unit 5) and the White-top Grassland (Map Unit 4). Seventy-seven taxa were recorded during the survey, and the vegetation was dominated by species from the families Chenopodiaceae and Poaceae. Three shrubs, the exotic weed *Lycium ferocissimum* and the natives *Rhagodia spinescens* and *Enchylaena tomentosa* occurred at more than 75% of sites. The distribution of vegetation communities was strongly associated with attributes of the soil (e.g. soil texture and organic carbon) and plant and litter cover. Vegetation communities occupying remnant sandhills such as the 'Zara' exclosure are some of the most vulnerable communities on the Riverine Plain.

Introduction

Sandhill remnants scattered across the Riverine Plain support restricted and vulnerable plant communities. Their small size, narrow shape and distance from other natural areas render them vulnerable to weed and pest invasion, and continued disturbance by livestock and feral herbivores. Grazing and disturbance and clearing and cultivation for agriculture result in declining recruitment and/or higher mortality of understorey species, and eventually loss of native vegetation cover (Porteners 1993). These sandhill remnants are becoming increasingly valuable for the survival of diminishing plant communities and their associated species (Eardley 1999). Maintenance of these sandhills as 'conservation islands' within a modified landscape depends on our knowledge of the current pressures and threats to these communities.

Only a few remnants, including the 'Zara' exclosure, closely represent the vegetation that once covered the sandhills of the south-west Riverina prior to European occupation.

The 'Zara' source-bordering dune (sandhill), has been recognised for its high biodiversity and conservation value. Brickhill (1985) recommended that the *Callitris*-dominated community at 'Zara' be given high conservation priority, and Porteners (1993) subsequently recommended that regeneration of the site be initiated. The Southern Riverina Naturalists also recognised the conservation value of the 'Zara' sandhill, and it was eventually fenced off from surrounding grazing land in May 1997. The fencing of the 60 ha sandhill site was supported by station owners F.S. Falkiner and Sons, with funding provided through the Drought Landcare Program of New South Wales National Parks and Wildlife Service. Greening Australia, Conservation Trust Volunteers, Windouran Shire Council and the Deniliquin Rural Lands Protection Board also provided support.

Previous work on vegetation communities on sandy soils on the Riverine Plain has been limited to species inventories, or general discussions of the sandhills in the context of the plain. Little is known about the relationships between plants and soils on these sandhill remnants, and there has been no attempt to quantitatively describe the links between the structure of the communities and the components of the soils and landforms.

Broad regional studies, species lists, management and technical reports, rangeland reviews and literature surveys have been undertaken by the Soil Conservation Service of NSW (Department of Land and Water Conservation), the National Herbarium of NSW, and by individuals such as Moore (1953), Leigh and Mulham (1977) and Cunningham et al. (1981). Porteners (1993) mapped the vegetation of the 'Hay Plain' which covered an area of 4.5 million hectares at a scale of 1: 250 000. Benson et al. (1997) also provide a recent and detailed description of the grasslands of the Riverine Plain.

The objective of this study was to describe the vegetation and soils, and their interrelationships, within the 'Zara' exclosure, and to provide base-line information against which future changes to the vegetation and soils could be compared. The ultimate aim is to provide objective information on which to support the management of the exclosure.

Study area

The study site is located on the Riverine Plain in south-western New South Wales. The Plain is a large expanse of flat alluvial landscape bordered by Narrandera and Balranald, and Ivanhoe and Bendigo. The exclosure is located within 'Zara', a grazing property located approximately 40 km north of Deniliquin, or 10 km east of Wanganella (35°10'21"S, 144°41'59"E) (Fig. 1). The principal land use in the area is sheep grazing on native pastures. The surrounding vegetation is typical of the Riverine Plain with annual grasses such as barley grass (*Hordeum leporinum*) and ryegrass (*Lolium rigidum*) comprising substantial proportions of the pasture. Smaller areas are used for irrigation and dryland cropping.

Isolated sandhills supporting the *Callitris glaucophylla* assemblage occur throughout the region. Those that occur within State Forests, as well as being subject to logging, are often leased out to landholders, and suffer intensive grazing pressure with little or no generation of tree species (Porteners 1993).

While the 'Zara' exclosure is by far the best remaining example of the *Callitris*-dominated community present in the region, it cannot be considered pristine. 'Zara' has been managed as a typical sheep grazing property for the past 150 years. The homestead is located approximately 500 m west of the sandhill, and consequently the

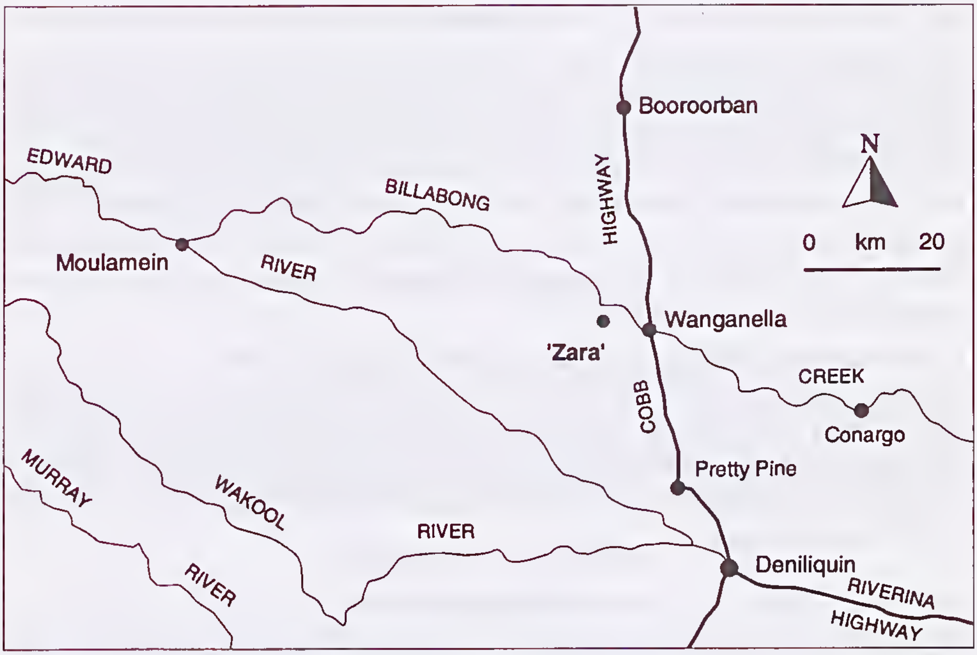

Fig. 1. Location of the 'Zara' exclosure in south-western New South Wales (adapted from Semple 1990).

sandhill would have formed part of the horse paddock surrounding the homestead. Grazing by sheep and cattle would have been intermittent, probably for short periods, as most managers tried to encourage a buffer strip around their homesteads to lessen the impact of dust storms. Ms Officer, the wife of one of the owners in the early part of the century was a keen naturalist, and collected many plant species from the sandhill. Some of her collection is housed at the National Herbarium of NSW. In the 1930s and 1940s the sandhill was apparently used as a golf course, suggesting that shrub cover would have been much less than it is today. Fencing, to exclude rabbits and domestic animals but not kangaroos, was carried out in 1997 using rabbit-proof netting.

The importance of the 'Zara' exclosure cannot be underestimated for several reasons. The exclosure, as well as officially recognising the conservation importance of the sandhill vegetation, encourages future and longitudinal studies of this sandhill. There is already evidence that the rabbit- and sheep-proof fencing has enhanced the regeneration of tree species such as rosewood (*Alectryon oleifolius*) and sugarwood (*Myoporum platycarpum*). Fencing has also enabled the Riverina Field Naturalists to strategically control african boxthorn (*Lycium ferocissium*) within the exclosure and within a buffer strip around the exclosure. Rabbit control has also been initiated with the use of 1080 baiting and warren ripping.

Climate

The climate of the Riverine Plain can be classified as semi-arid, with very hot summers, mild winters and a winter dominant rainfall (Edwards 1979). For the months of January and February, the average daily maximum is approximately 32°C and the average daily minimum for July is about 4°C for the whole of the Riverine Plain (O'Halloran 1995). 'Wanganella', east of 'Zara', has a mean annual rainfall of 337 mm and an average of 53 rain days (Bureau of Meteorology 1998). January and February are the driest months at 'Wanganella', while peak rainfall occurs in May and September (Benson et al. 1997).

Evaporation rates are high, especially in summer and autumn when rainfall is largely ineffective (O'Halloran 1995). Frosts are common between May and September (Cunningham et al. 1981). The most common wind directions are from the south and south-east, although in winter and spring a westerly influence is common. Wind is an important factor in the formation of landforms such as sand dunes which are common on the Riverine Plain.

Landforms and soils

The area surrounding the 'Zara' sandhill consists mostly of alluvial and lacustrine deposits of clay, silt, sand and gravel (Semple 1990). Geomorphically, the sandhill can be described as a source-bordering sandhill which has been derived from the redistribution of coarse stream bed deposits of prior streams and, to a lesser extent, ancestral rivers (Butler et al. 1973). The sandhill is gently sloping, orientated west-east, and was stabilised by vegetation prior to European settlement.

The soils of the 'Zara' sandhill consist of a mixture of siliceous and earthy sands which have a relatively uniform profile with only small changes in colour and texture with depth (Eldridge 1990). The sands are also low in fertility and are highly susceptible to wind erosion once the stabilizing vegetation is removed. Red and brown texture contrast (duplex) soils occur at the margin of the sandhill and the plain. Their surface textures are generally coarse sandy to loamy sands, grading to clayey subsoils often with carbonate at depth. Texture contrast soils are susceptible to windsheeting and scalding (Eldridge 1990).

Vegetation

Much of the Riverine Plain, particularly in the western section, supports chenopod shrubland dominated by *Atriplex vesicaria* and *Maireana aphylla*, and to a lesser extent *Atriplex nummularia* (Porteners 1993). To the east this shrubland has been replaced by a grassland dominated by *Notodanthonia caespitosa* and other perennial and annual grasses. Much of the Riverine Plain has been modified by grazing which has led to a change in vegetation community from *Atriplex vesicaria* to *Sclerolaena* spp. and annual *Atriplex* spp. Grazing pressure has also encouraged the dominance of *Nitraria billardieri* and annual grasses such as *Hordeum leporinum*. On rangelands which are periodically inundated, *Atriplex vesicaria* is often replaced by *Maireana aphylla*.

The Southern Riverina Naturalists compiled a list of 129 species from 44 families from the 'Zara' Exclosure (Mulham, unpublished data). Whilst this study provided a valuable initial assessment of the conservation value of the exclosure, no attempt was made to rate the abundance, importance, or uniqueness of the species within the exclosure or to relate these species to the underlying environmental attributes that determine species distribution.

Field Methods

Establishment of permanent grid points

Sixty permanent grid points were marked out at regular intervals of 30 m by 30 m across the exclosure. The points were identified on a 1: 10 000 black and white aerial photograph before being marked permanently in the field with numbered steel pegs.

Vegetation measurements

At each point a circular plot of 10 m radius was established for the collection of plant and soil data. Cover and abundance of each plant species were assessed during summer (January 1998) at each site using a modified Braun-Blanquet scale where: 1 = < 5% cover and < 5 individuals, 2 = < 5% cover and > 5 individuals, 3 = 5–25% cover, 4 = 25–50% cover, 5 = 50–75% cover, and, 6 = > 75 % cover (Mueller-Dombois and Ellenberg 1974). The botanical names used in this report follow Harden (1990–1993).

Soil surface condition assessment and soil sampling

At each site, attributes of the soil surface were measured in two 0.25 m^2 quadrats placed on opposite sides of the 10 m radius plot. Methods for assessing soil surface condition (Table 1) were adapted from Tongway (1995).

Table 1. Environmental variables used in the Canonical Correspondence analysis.

Variable	Code	Range of values	Description
slope	SLOPE	(1–5)	0% (1) to > 10% (5)
microtopography	MICRO	(1–5)	< 3 mm (1) to > 100 mm (5)
crust coherence	COHER	(1–5)	sand (1) to non-brittle or self mulching (5)
cracking	CRACK	(1–4)	extensively broken (1) to intact (4)
firmness	FIRM	(1–4)	very loose (1) to firm (4)
cryptogams	CRYPT	(1–4)	< 1% (1) to > 50% (4)
erosion amount	SHEET	(1–4)	extensive (1) to insignificant (4)
soil cover	PCOV	(1–5)	< 1% (1) to > 50% (5)
basal cover	BCOV	(1–4)	< 7 mm (1) to > 140 mm (4)
simple litter cover	LCOV	(1–6)	< 10% (1) to 100% (several cm thick) (6)
litter source	SOURCE	(1–2)	transported (1) to local (2)
litter incorporation	LCORP	(1–3)	low (1) to extensive (3)

Slope within the site was classified as 0%, 1–3%, 3–5%, 5–10% or > 10%. **Surface microtopography**, defined as the vertical difference between the highest and lowest point at the site, was recorded. Increases in this vertical difference, increases the soil's potential to retain and store rainfall, leading to potentially higher biological activity. The five classes were; < 3 mm, 3–8 mm, 8–25 mm, 25–100 mm and > 100 mm.

Crust coherence gives a measure of the crust's resistance to disruption, and is assessed as the resistance of the soil surface to an object equivalent to the diameter of a pencil. The 'resistance' indicates the ability of the surface to resist stress immediately upon wetting, or to reform after wetting (Tongway 1995). Crust coherence classes were ranked as: sandy (single grained), easily broken, moderately hard, very hard, non-brittle or self mulching (clay aggregates). Increasing number corresponds to the soils increasing predisposition to hardsetting.

Soil firmness or stability when subject to raindrop impact was estimated in the field. The categories were ranked as firm, moderately firm, loose or very loose. The less firm a soil the more potential there is for erosional loss of fines and greater impermeability on drying (Tongway 1995).

Relative cracking was measured by estimating the percentage of the soil surface covered by cracks. This relates to what degree the surface material is loosely attached and therefore its capacity to disintegrate and erode. It may also be related to the potential for microsites and consequently seed lodgement. Four categories were used: extensively broken, moderately broken, slightly broken and intact.

The cover of cryptogams, grass butts and understorey plants was measured to indicate the degree of cover on the soil at each site and therefore to determine the soil's ability to resist erosion. **Cover of cryptogams** (microphytic crusts; Eldridge & Greene 1996) was classified as: < 1 %, 1–10 %, 10–50 % or > 50 %. As cryptogams are a positive indicator of stability, increasing cover equates with a more stable soil (Tongway 1995).

The **grass basal cover** was estimated in the following classes: 7 mm, 7–70 mm, 70–140 mm or > 140 mm. These values indicate the contribution that the underground biomass (roots) is making to the nutrient pool (cycling). The **plant cover** values indicate the degree to which foliage cover of perennial grasses and any perennial shrubs, less than 0.5 m above the ground, protects the soil surface from rainsplash erosion. Because of the greater potential of gravity drops falling from the foliage of trees and shrubs taller than 0.5 m to erode soil, only foliage of vegetation < 0.5 m was included (Tongway 1995). The cover was estimated as: < 1 %, 1–15 %, 15–30 %, 30–50 % and > 50 %.

The percentage of **soil covered by litter** was recorded, along with an assessment of whether this litter was local or transported, and the degree of incorporation into the soil. The percentage of litter cover was represented by six classes: < 10%, 10–25%, 25–50%, 50–75%, 75–100% or 100% but several centimetres thick. The litter was either transported (material originated elsewhere and can be more easily lost) or local. The incorporation of this litter was assessed to be either low, moderate or extensive.

The **degree of erosion** at a site was classed as extensive, moderate, slight or insignificant. This gives an indication of the severity of active or current loss of soil material (Tongway 1995). If evidence of erosion existed, then the type (sheeting, scarping, scalding, terracing, hummocking, rills or gullies) was noted, and the eroded material (sand, gravel or clay) was recorded. The types recorded are defined in Tongway (1995).

Four soil samples were collected from a depth of 10 cm from within each circular plot and bulked for an assessment of soil chemical properties.

Organic carbon (OC) was determined using the modified Walkley-Black method (Colwell 1969). Replicates of a 1:5 soil and water solution were used to measure the hydrogen ion concentration (pH) and electrical conductivity (EC) after shaking. Soils were assigned to six texture (TEXT) classes (sands, sandy loam, loams, clay loam, clay) using the bolus method of Northcote (1979).

Data analysis

Vegetation relationships

A species-by-site matrix was constructed to examine groupings of the 60 sites based on cover-abundance of the vascular plants. Of the 77 species recorded, 37 were eliminated from the analysis as they occurred in < 7 (10%) of the sites. The aim of this reduction was to increase the clarity and simplicity of the interrelationships between sites and species, and to reduce the impact of locally 'rare' or infrequent species upon this interpretation.

The reduced data matrix of 60 sites by 40 species (including exotic species) was classified using an hierarchical agglomerative cluster analysis using the Bray-Curtis dissimilarity measure and the Ward's Incremental Sum of Squares (WISS) grouping strategy (Belbin 1990). This analysis produced a grouping of sites that were relatively 'similar' to each other but relatively 'different' to all sites in other groups based on the cover-abundance of species. Unweighted pair group method using arithmetic averages (UPGMA) was also used to cluster the sites in order to determine the robustness of the clusters. An optimal number of groups (Map Units) was determined by examining the point of inflection on a plot of the number of possible groups by dissimilarity level.

Correlations between the number of species and the number of exotics recorded for each Map Unit were determined using Pearson's correlation coefficient (*r*). Species richness (the average number of species within each Map Unit) was calculated. A measure of diversity, the Shannon-Wiener index, was calculated to account for the varying patterns of species abundance.

Relationships between vegetation and environmental variables

Canonical Correspondence Analysis (CCA) using CANOCO Version 2.1 (ter Braak 1991) was used to examine relationships between the measured environmental variables and the distribution of species within the exclosure. The environmental variables are represented by vectors whose length indicates the relative importance of each variable in determining the axes. The angle between a vector and an axis is an inverse measure of their correlation. The location of species scores relative to the environmental variables indicates those species or groups of species which have the greatest affinity with the measured environmental variables (ter Braak 1986).

Of a total of 24 environmental variables, nine were omitted from the CCA either to increase the clarity of the relationship between soil variables and species distribution or because the values for some variables did not change across the 60 sites. An environmental data set matrix was constructed using 120 rows (60 sites by 2 quadrats per site) by 15 environmental variables. The environmental variables include the 12 listed in Table 1, as well as soil texture (TEXT), organic carbon (OC) and electrical conductivity (EC). The significance of the environmental variables was tested using a Monte Carlo simulation in the CANOCO package (ter Braak 1991). Accordingly, all insignificant environmental vectors were omitted from the CANOCO biplots. Relationships between the environmental variables and the 60 sites were examined by projecting the 60 site locations, coded for Map Unit, onto the first two axes of the CCA biplot.

Statistical analysis

Data were tested for normality and homogeneity of variance and transformed where necessary ($\log_{10}$, reciprocal, y^3) to meet parametric assumptions. Differences in richness and diversity were tested using one-way analysis of variance (ANOVA) and significant differences determined using Tukey's H.S.D. test. Data which were not normally distributed, or which had unequal variances, were tested using the non-parametric Kruskal-Wallis test (Minitab 1989).

Results

Floristics of the 'Zara' exclosure

Seventy seven taxa (species and subspecies) representing 32 families and 65 genera were recorded in our study (Appendix 1). Together with those species recorded by the Southern Riverina Field Naturalists (Mulham, unpublished), a total of 144 taxa (43 families, 110 genera) have been recorded in the exclosure (Appendix 1). The ROTAP species (*Ptilotus extenuatus*) and a Schedule I species under the Threatened Species Act (*Calotis moorei*) both recorded from the sandhill, were not found during the current survey or by the Riverina Field Naturalists.

As the survey of the 'Zara' exclosure was made at only one point in time, i.e. a hot summer with below average rainfall, a large number of species normally found in the area were not encountered. As a large number of annuals in the Riverina are winter growing (Leigh & Mulham 1977), only summer growing species and the main drought tolerant or drought avoiding plants were recorded. This may explain why only 20 of the 44 known exotics were found during the current survey.

Families known to contain a conspicuous number of exotics such as Poaceae, Brassicaceae and Boraginaceae occurred at more than half of the sites sampled (Table 2). Only 12 species occurred in more than half of the sites (Table 3), and of these three were exotic, and included the declared noxious weed *Lycium ferocissimum*. Examination of Table 3 and Appendix 1 indicates that *Rhagodia spinescens* and *Enchylaena tomentosa* occurred in more than 45 sites and in all Map Units. These shrubs, from the family Chenopodiaceae, could be regarded as characteristic of the 'Zara' exclosure. A high proportion (48%) of species occurred in less than 10% of the sites.

Table 2. The most common families surveyed within the exclosure.

[1]frequency is out of a total of 77 (the total number of species found in the present study), [2]frequency is out of a total of 144 (the total number of species found in the present study and Mulham's unpublished study).

Family	No. of sites occupied	Frequency[1] of species found during the current survey (% out of 77)	Frequency[2] of species found for 'Zara', overall (% out of 144).
Chenopodiaceae	60	15 (19%)	16 (11%)
Poaceae	60	13 (17%)	24 (17%)
Aizoaceae	38	1 (1%)	1 (1%)
Brassicaceae	38	2 (3%)	4 (3%)
Santalaceae	38	3 (4%)	3 (2%)
Boraginaceae	36	3 (4%)	3 (2%)
Sapindaceae	34	2 (3%)	2 (1%)
Fabaceae	33	5 (7%)	10 (7%)
Solanaceae	32	3 (4%)	3 (2%)
Asteraceae	11	5 (7%)	22 (15%)

Table 3. The most common species found during the survey.

Frequency refers to the number of sites, out of 60, where the particular species was found. *indicates an exotic species.

Species Name	Frequency	Family
Rhagodia spinescens	58	Chenopodiaceae
Stipa spp.	50	Poaceae
Enchylaena tomentosa	45	Chenopodiaceae
Bromus arenarius	45	Poaceae
**Mesembryanthemum crystallinum*	38	Aizoaceae
Enteropogon acicularis	36	Poaceae
Notodanthonia caespitosa	35	Poaceae
Stipa elegantissima	33	Poaceae
**Echium plantagineum*	33	Boraginaceae
Exocarpos aphyllus	32	Santalaceae
Dodonaea viscosa subsp. *angustissima*	31	Sapindaceae
**Lycium ferocissimum*	30	Solanaceae

Vegetation groupings based on site classification

The dendrogram (Fig. 2) indicated that six groups (Map Units) provided the most appropriate level of detail for mapping the vegetation in the exclosure. These six Map Units corresponded to three intergrading vegetation communities found on the Riverine Plain (Cunningham et al. 1981, Semple 1990, Porteners 1993), and closely reflect the vegetation patterns observed on the aerial photograph (Fig. 3).

Species found within each of the six Map Units, and the percentage of sites occupied by each species within a Map Unit are shown in Appendix 1. While Map Units 1 to 5 lay within generally well-defined communities, boundaries between these units are gradational. Map Unit 6 represents a transition from one community to another. As Map Units 1, 2, 3 and 6 have similar complements of species compared to Map Units 4 and 5, these units are discussed together. In discussion of Map Units 1, 2, 3 and 5, superscripts indicate the Map Units in which the species occur, and no superscript indicates occurrence in all four Map Units.

Map Units 1, 2, 3 and 6: *Callitris* Mixed Woodland

Map Units 1, 2, 3 and 6 correspond to the *Callitris* Mixed Woodland described by Porteners (1993). See Figs 3 and 4. *Callitris glaucophylla* was abundant in Map Unit 1 but scattered in Map Units 2 and 3. *Alectryon oleifolius* subsp. *canescens*, which was scattered within Map Units 1 and 2, appears to replace *Callitris glaucophylla* as the latter diminishes. The understorey consisted of *Rhagodia spinescens*, *Dodonaea viscosa* subsp. *angustissima*, *Hakea tephrosperma*^{12}, *Eremophila longifolia*, *Atriplex nummularia*^{23} and *Enchylaena tomentosa*. *Lycium ferocissimum* and *Exocarpos aphyllus* were also found in Map Units 1, 2, 3 and 6.

Ground flora comprised short-lived annual and perennial grasses and herbs, many of them exotics (Porteners 1993). These included *Mesembryanthemum crystallinum*^{123}, *Bromus arenarius*, *Stipa* spp., *Echium plantagineum*, *Stipa elegantissima*, *Notodanthonia caespitosa*^{236} and *Sisymbrium erysimoides*^{12}. Species found at a low number of sites included *Sisymbrium orientale*, *Schismus barbatus*, *Einadia nutans*, *Hordeum leporinum* and *Jasminum lineare*. *Vulpia myuros* was abundant in Map Units 1, 3 and 6, while *Atriplex nummularia* and *Trifolium arvense* characterized both Map Units 2 and 3. Map Unit 6 was characterized by the absence *of Mesembryanthemum crystallinum* and a very low cover-abundance of *Dodonaea viscosa* subsp. *angustissima*.

Map Units 1 and 2 accounted for the greatest coverage of the exclosure (Fig. 3), and supported the greatest number of either native or exotic species. The number of exotics and the total number of species, for each Map Unit, were significantly positively correlated ($r = 0.91$, $P < 0.02$). Of the four Map Units included in the *Callitris* Mixed Woodland, only Map Units 1 and 2 had unique species. Of the 71 species within the *Callitris* Mixed Woodland, 29 were absent from both Map Units 4 and 5.

Map Unit 4: White-top Grassland

Map Unit 4 corresponded to Porteners (1993) White-top Grassland with the perennial grass *Notodanthonia caespitosa* abundant at all sites (Fig. 5). Associated grasses of high abundance included the perennials *Stipa* spp., *Enteropogon acicularis*, *Elymus scaber* var.

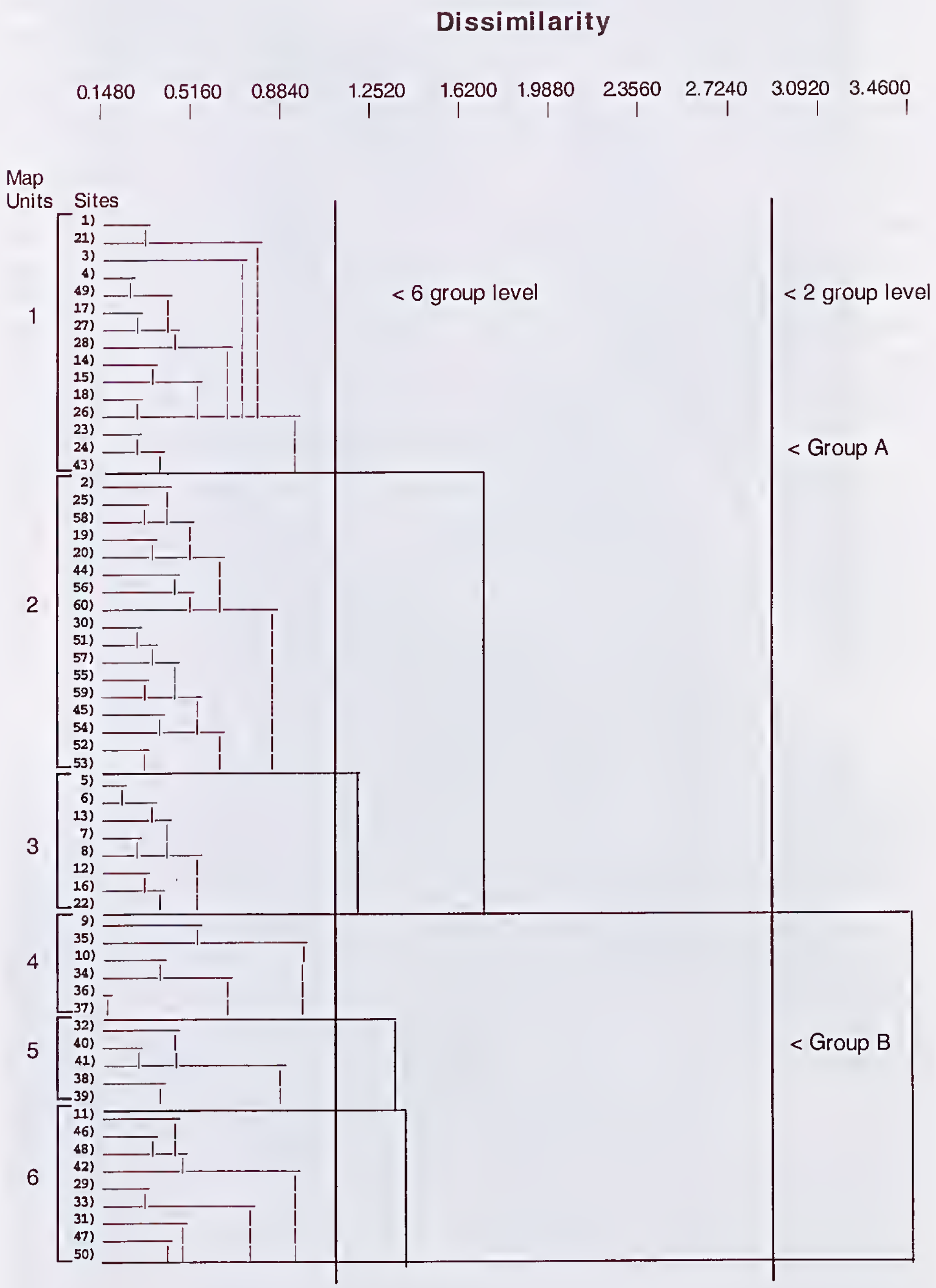

Fig. 2. Dendrogram showing the classification of the 60 sites into the six Map Units based on species abundance and cover.

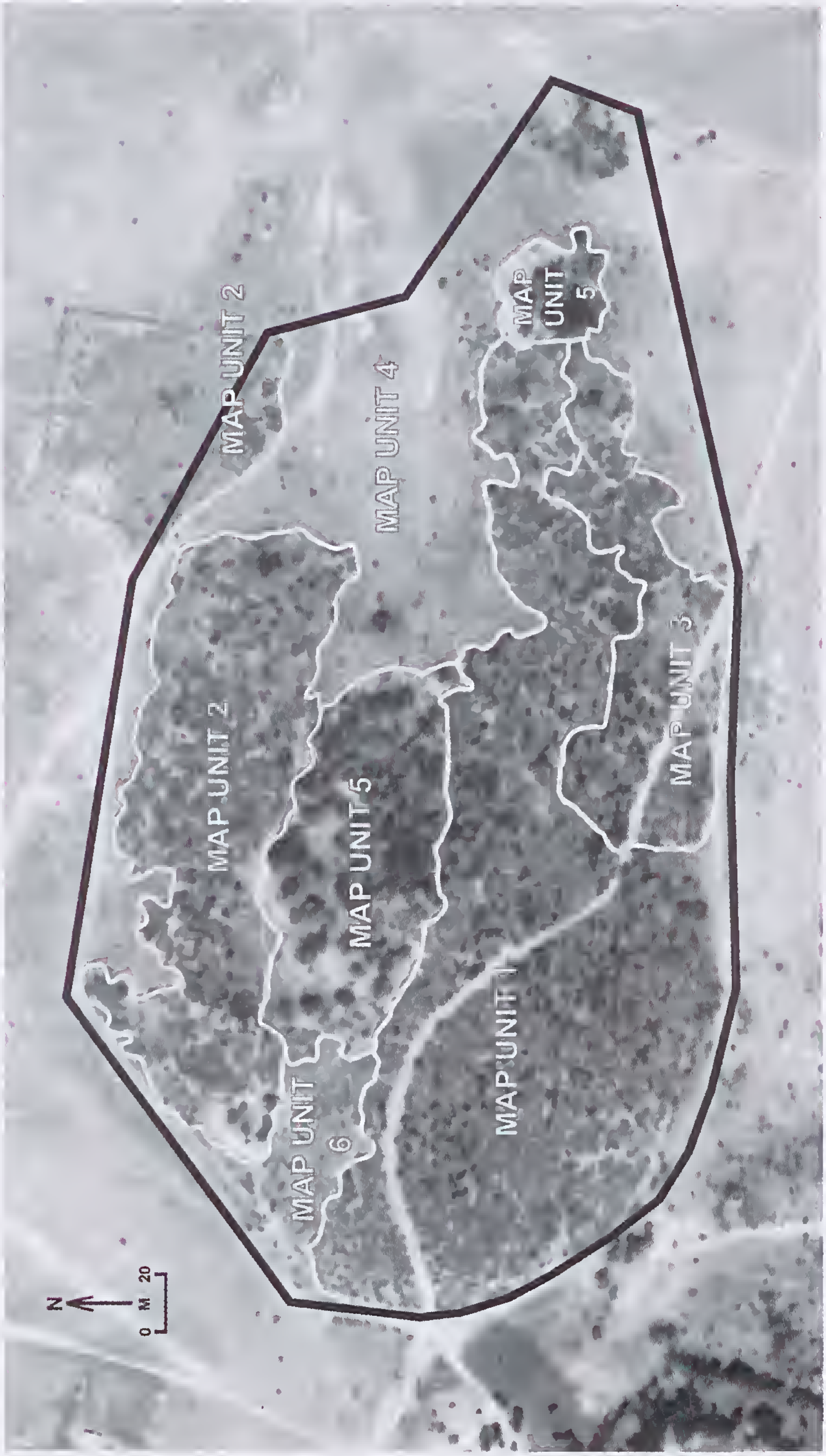

Fig. 3. Distribution of the six Map Units and three vegetation communities defined by cluster analysis.

scaber and the exotic annual *Hordeum leporinum*. Associated forbs included the annual weed *Echium plantagineum*, and the perennial *Maireana pentagona*. Perennial shrubs *Rhagodia spinescens*, *Atriplex semibaccata* and *Enchylaena tomentosa* were also associated with *Notodanthonia caespitosa* in Map Unit 4.

Apart from the absence of trees and taller shrubs, Map Unit 4 is distinguished from the other units by the absence of *Bromus arenarius*, *Stipa elegantissima*, *Sisymbrium orientale* and *Lycium ferocissimum*. This unit also has the lowest mean number of species per site, the lowest total number of species, and the lowest number of exotics.

Statistically, the lower species diversity of the White-top Grassland (Map Unit 4) was significantly different to the higher diversity of the *Callitris* Mixed Woodland (Map Units 1, 2, 3 and 6; $F_{5,54} = 5.01$, $P < 0.05$). Species richness was also greater for Map Units 1, 2 and 3 of the *Callitris* Mixed Woodland which was significantly different to the lower species richness of the White-top Grassland (Map Unit 4; $F_{5,54} = 7.68$, $P < 0.05$). Although these results give an indication of species richness and diversity across the site, the data are probably influenced by season.

Map Unit 5: Black Box Woodland

Map Unit 5 was characterised by a high cover-abundance of *Eucalyptus largiflorens* (Fig. 6). This unit accounted for the smallest coverage of the exclosure (Fig. 3) and included 29 native and 7 exotic species. The number of species per site ranged from 12 to 17. *Eucalyptus largiflorens* was associated with, in order of abundance, the perennial shrubs *Rhagodia spinescens*, *Enchylaena tomentosa*, *Exocarpos aphyllus*, *Einadia nutans* and

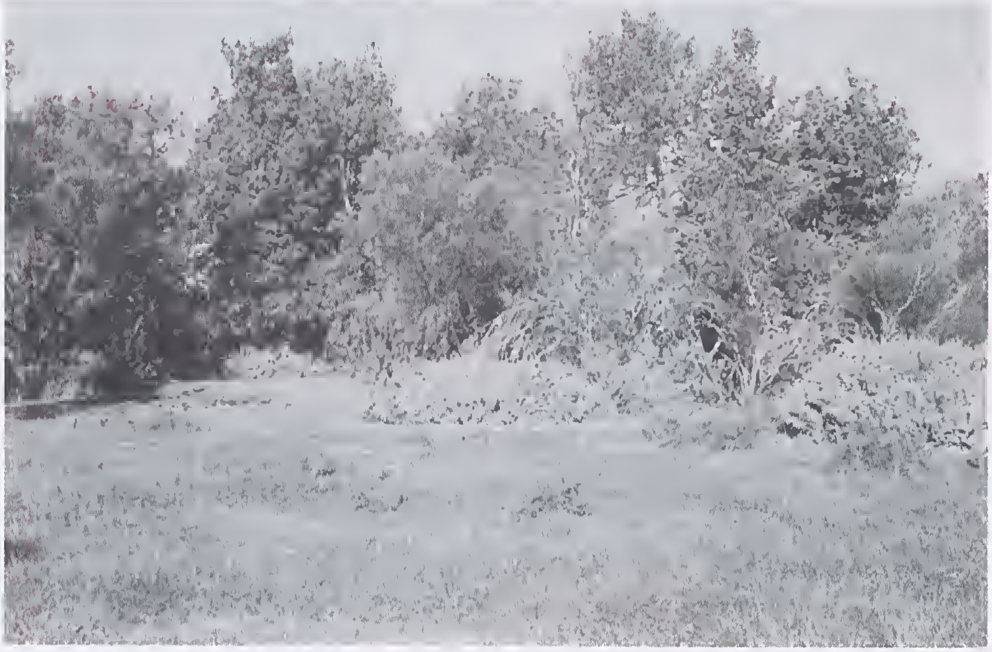

Fig. 4. *Callitris* Mixed Woodland with a *Rhagodia spinescens* and *Atriplex nummularia* understorey.

the noxious weed, *Lycium ferocissimum*. Associated ground flora included the perennial grasses *Notodanthonia caespitosa*, *Enteropogon acicularis*, *Stipa elegantissima* and the biennial exotic forb *Sisymbrium orientale*.

Apart from the absence of *Mesembryanthemum crystallinum* and *Dodonaea viscosa* subsp. *angustissima*, Map Unit 5 is distinguished from the other units by the notable absence of *Stipa* spp., *Bromus arenarius* and *Echium plantagineum*. Species endemic to Map Unit 5 were *Eriochlamys behrii*, *Spergularia rubra* and *Atriplex pseudocampanulata*.

Species-environment relations

Axes I and II of the CCA biplot (Fig. 7) accounted for 35.2% and 20.3% respectively of the variation in species distribution. The length of the vectors shown in Fig. 7 indicates the relative importance of the environmental variables in determining the two axes. Significant and important determinants of axis I were soil texture (proportion of sand in the soil), organic carbon, surface firmness, degree of cracking, crust coherence, cryptogam cover and electrical conductivity. Axis I consequently corresponded to a gradient of increasing clay content from left to right in Fig. 7. Plant cover, microtopography and litter cover were important determinants of axis II, with soil cover increasing from the top of Fig. 7 to the bottom. The angle between a vector and an axis provides an inverse measure of the relationship between the various environmental variables. As such, litter cover and plant cover are shown to be inversely related.

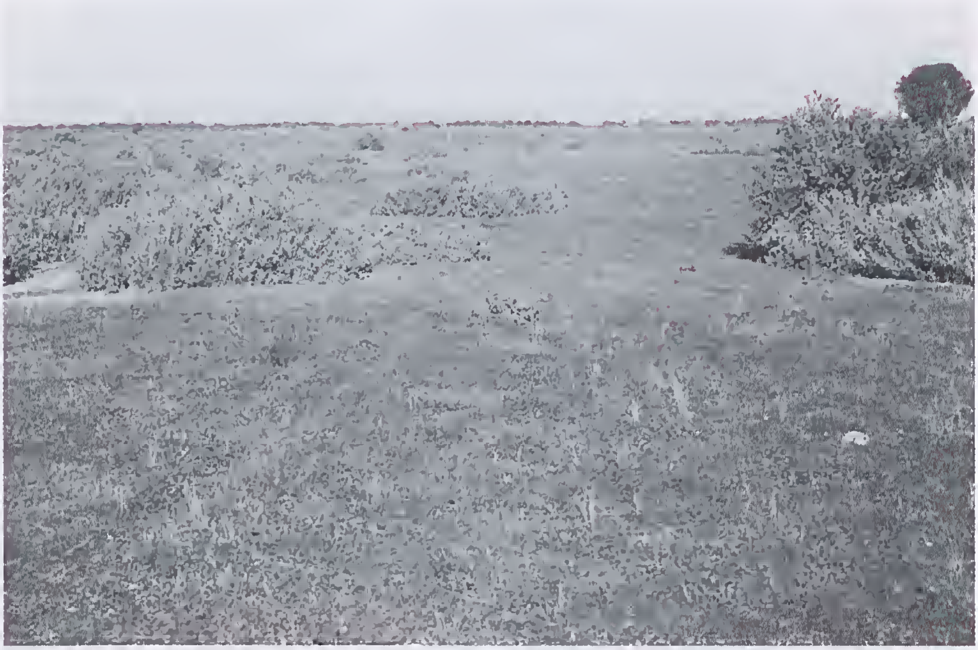

Fig. 5. White-top Grassland characterised by *Notodanthonia caespitosa* associated with *Stipa* spp., *Enteropogon acicularis* and some *Rhagodia spinescens* shrubs

The majority of the 30 species, including those omitted from the plot for cartographic reasons, were clustered close to the centroid (origin). These were generally species common at most sites (e.g. *Rhagodia spinescens* (Rgsp) and *Enchylaena tomentosa* (Ehlt)) or species which showed little affinity with any of the measured environmental variables. Some species however showed strong preferences for certain environmental variables. In the upper left-hand sector of the CCA biplot (Fig. 7) are those species which are correlated with sandy (coarse-textured) soils with moderate levels of litter cover. These include *Callitris glaucophylla* (Klta), *Alectryon oleifolius* subsp. *canescens* (Aleo) and *Dodonaea viscosa* subsp. *angustissima* (Ddat). *Hakea tephrosperma* (Hkts) showed an affinity with increasing levels of litter cover and reduced plant cover, whilst *Mesembryanthemum crystallinum* (Msbc) was associated with soils of reduced clay content, low electrical conductivity and sparse cryptogam cover. The above are the key species that define the *Callitris* Mixed Woodland. Their distribution on the biplot indicates their relative contributions in defining the community.

Two species, *Hordeum leporinum* (Hodl) and *Maireana pentagona* (Mapg; lower right sector) were associated with sites of high clay content and abundant plant cover. *Notodanthonia caespitosa* (Dacp), *Enteropogon acicularis* (Enta) and *Echium plantagineum* (Ekmp) are also associated with predominantly clay textured soil, although to a lesser extent. Those that were also correlated with rough soils (high microtopography), high foliage cover of plants, low levels of organic carbon and a lower clay content (lower left-hand sector), included *Citrullus lanatus* (Ctrl) and *Atriplex nummularia* (Atnm).

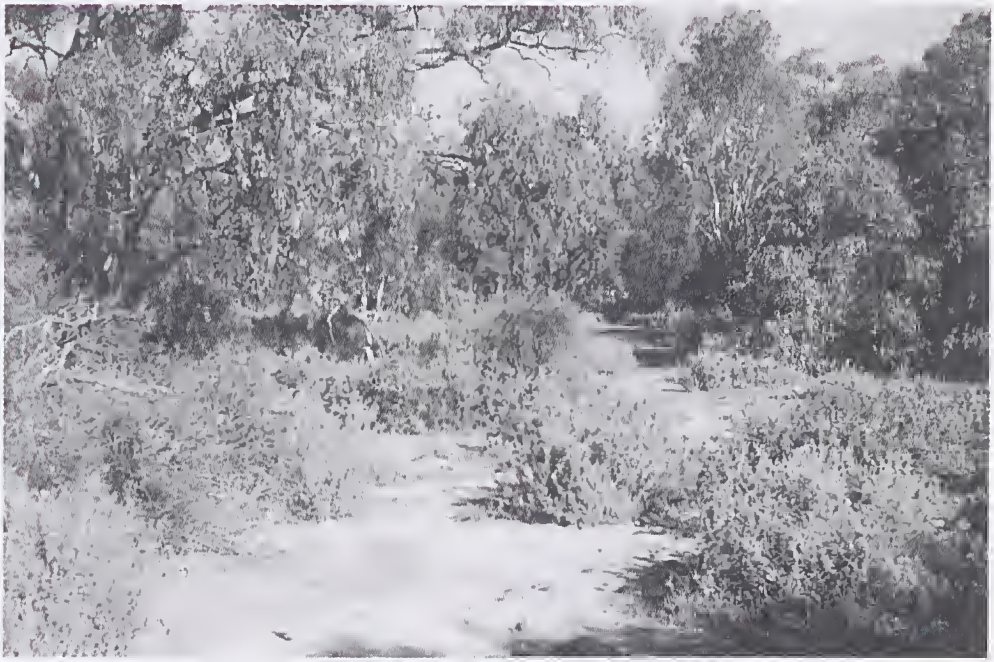

Fig. 6. Black Box Woodland dominated by *Eucalyptus largiflorens* with an understorey of *Rhagodia spinescens*.

Eucalyptus largiflorens (Uklf) occurred in the right hand sector of Fig. 7 and is strongly associated with sites of abundant litter cover, loamy soils (high organic carbon levels) and with a sparse foliage cover. *Einadia nutans* (Einn) and *Acacia salicina* (Aksa) also showed a similar association.

Soil surface condition

The soil surface in the exclosure was generally intact, moderately stable and uneroded, with low to moderate microtopography on low (< 3%) slopes (Table 4). Approximately half of the surfaces were non-coherent, and the majority of soils had sandy or sandy loam surface textures. Litter cover in the quadrats was moderate, locally derived i.e. not transported from elsewhere, and poorly broken down and incorporated into the soil surface. Predictably, given soil surface textures, cryptogam cover was sparse. While foliage cover of vascular plants was highly variable across the exclosure, basal cover was generally low. The dominant erosion form at the site was sheet erosion of sandy material.

Table 4. Distribution of the soil surface variables across the 60 sites.

Classes are shown in the first row, and the percentage of each class is given in the second row.

A. Slope (%)	**0**	**1–3**	**3–5**	**5–10**	**> 10**	
	11	86	2	1	0	
B. Microtopography (mm)	**< 3**	**3–8**	**8–25**	**25–100**	**>100**	
	7	40	42	11	0	
C. Crust coherence	**Sand**	**Easily broken**	**Moderately hard**	**Very hard**	**Non-brittle or self-mulching**	
	11	43	14	22	10	
D. Cracking	**Extensively broken**	**Moderately broken**	**Slightly broken**	**Intact**		
	0	2	8	90		
E. Firmness	**Very loose**	**Loose**	**Moderately firm**	**Firm**		
	0	0	67	33		
F. Cryptogams (%)	**<1**	**1–10**	**10–50**	**> 50**		
	65	19	13	3		
G. Sheet erosion	**Extensive**	**Moderate**	**Slight**	**Insignificant**		
	0	3	23	74		
H. Soil cover (%)	**< 1**	**1–15**	**15–30**	**30–50**	**> 50**	
	11	31	30	21	7	
I. Basal cover (mm)	**< 7**	**7–70**	**70–140**	**> 140**		
	62	29	8	1		
J. Litter cover (%)	**< 10**	**10–25**	**25–50**	**50–75**	**75–100**	**100 (several cm thick)**
	14	26	38	15	5	2
K. Litter source	**Local**	**Transported**				
	100	0				
L. Litter incorporation	**Low**	**Moderate**	**Extensive**			
	71	12	17			
M. Texture	**Light Clay**	**Clay loam**	**Loam**	**Sandy loam**	**Sand**	
	2	8	18	43	29	

The CCA biplot (Fig. 8) indicated that a change in vegetation community from the *Callitris* Mixed Woodland (left hand side), to the White-top Grassland (bottom right) and Black Box Woodland (top right) can be described in terms of two environmental gradients: a gradient in surface soil texture and a gradient in organic carbon and litter cover. Map Units 1, 2, 3 and 6 were generally associated with coarser textured (sandier) soils with a wide range of soil and litter cover levels. Map Unit 5 was associated with increasing organic carbon (loamier soils) and increasing litter cover, whilst Map Unit 4 was associated with both increasing clay content and decreasing litter cover (Table 5, Fig. 8).

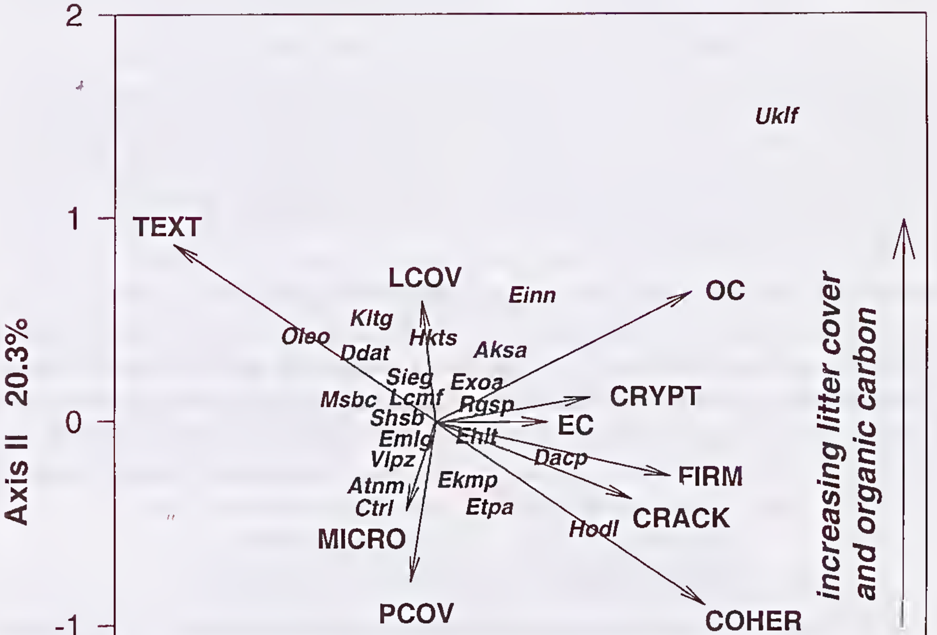

Fig. 7. Species-environment biplot for axes I and II after the Canonical Correspondence Analysis. Species names and codes are given in Appendix 2.

Soil chemical characteristics

Overall, the soils within the exclosure were non-saline ($EC_{1:5} < 0.40$ dS/m) and slightly acidic, with low percentages of organic carbon (Table 6). Electrical conductivity (EC) on Map Units 1, 2 and 3 were significantly lower than for Units 4 and 6 ($P < 0.05$), whilst Map Unit 5 was not significantly different to the other units.

Discussion

Floristics

Eighty-two percent (49) of the 60 sites in the 'Zara' exclosure corresponded to Porteners' (1993) *Callitris* Mixed Woodland, and the remainder corresponded with the Black Box Woodland and the White-top Grassland units. The *Callitris* Mixed Woodland had significantly greater species richness and diversity (Shannon-Weiner index) compared with the White-top Grassland and Black Box Woodland.

Consistent with other studies of the Riverine Plain and surrounding areas (Semple 1986, 1987, Porteners 1993, Sivertson & Metcalfe 1995), the Poaceae, Asteraceae, Chenopodiaceae and Fabaceae families were most represented (Table 2). Of the 977 species recorded for the Riverine Plain as a whole (Porteners 1993), 144 have been recorded at 'Zara' (Appendix 1)

The small number of species in common with other studies can be explained by two main factors. Firstly, the present study was conducted at only one point in time, during a very dry summer. Consequently, only summer-growing and/or drought tolerant plants were recorded. Further collections made during winter/spring or after rain are likely to increase the number of species recorded, particularly annuals and ephemerals. Secondly, as the exclosure is less than 60 hectares in area, it represents only a small proportion of the landscapes found over the Riverine Plain.

Relationships between soils and vegetation

In our study, the distribution of communities was closely associated with a range of environmental variables including soil texture, cracking, coherence, stability, organic carbon, plant cover and litter cover (Fig. 7). In general, the *Callitris* Mixed Woodland was associated with sandy, coarse-textured soils, the Black Box Woodland with loamier soils, and the White-top Grassland with finer clay-textured soils (Fig. 8). Soil texture, by influencing soil moisture availability, is known to be a critical determinant of species distribution (Noy-Meir 1974, Eldridge 1988).

Within the White-top Grassland, moisture availability is strongly influenced by the high clay content of soils (Williams 1956). Despite surface ponding, the high shrink swell capacity of clays limits the depth of water infiltration to approximately 30 cm (Eldridge 1988). Available water for plants is then limited by the high water holding capacity of the soils. Consequently, the vegetation within Map Unit 4 is dominated by short-lived ephemerals, perennial grasses and perennial shrubs such as *Maireana pentagona* which have shallow, lateral roots confined to the top 30 cm of the soil. The limited water availability for plants, the difficulty for roots to penetrate the hardsetting soils (Williams 1956), the extensive cracking of the soil and the generally high salinity levels means that trees are generally restricted to either sandy rises, prior stream levees, or active watercourses (Semple 1990).

The combination of loamy soils with heavy clay subsoils, abundant litter and the probability of low water availability (due to the dense cover of *Eucalyptus largiflorens*), is probably responsible for the sparse plant cover in the Black Box Woodland sites (Table 5). Despite this sparse plant cover, compared with that in the *Callitris* Mixed Woodland (Fig. 8), the dense litter cover on these soils, a contribution from the upper canopy, is sufficient to protect the surface against raindrop impact, preventing soil slaking and surface sealing, and reducing overland flow of water and sediment movement. Litter also improves the condition of the soil by providing a source of organic matter, encouraging soil biota, leading to greater levels of porosity and therefore infiltration (Eldridge & Koen 1993).

In contrast to the clay soils, the earthy sands of the *Callitris* Mixed Woodland are highly permeable (Eldridge 1989), and characterised by low levels of organic carbon, and consequently low levels of electrical conductivity (Table 6). The deeper, sandier soils of the dune crest supported *Callitris glaucophylla* and shrubs such as *Dodonaea viscosa* which occur on sandplains and dune fields in the north-west of NSW at relatively high densities (Hodgkinson 1992). In sandy soils, a combination of relatively deeper penetration of water, and the availability of much of this moisture for germination, means that, compared with clay soils, sands respond much more rapidly to small falls of rain (Johns et al. 1984). As rainfall in the area is generally winter-dominant, much of the ephemeral growth at the time of the study is likely to be restricted to the sandy soils. This probably accounts for the relatively larger number of ephemeral species found on the sandy soils and perhaps the large numbers of weedy species compared with the clay soils.

Management of the 'Zara' exclosure

The Riverine Plain has been grazed by domestic livestock for more than 150 years, and is a severely modified landscape (Benson 1988). Fragmentation has left the exclosure isolated from other sandhills, and with a large perimeter across which exotic plants can penetrate. Monitoring of vegetation cover, invasion of exotics (both plants and animals) as well as soil health is an essential component of the management of 'Zara'. Strategies such as minimising disturbances in and around the exclosure to prevent the spread of exotics, and fencing of a buffer strip around the exclosure are likely to enhance the conservation value of the exclosure.

The present survey indicated that the vegetation communities at 'Zara' have already been substantially modified by the invasion of exotic weeds such as *Lycium ferocissimum*, and currently support relatively high abundances of common Mediterranean weeds such as *Citrullus lanatus* var. *lanatus*, *Mesembryanthemum crystallinum* and *Echium plantagineum*. Dispersal of these exotics is enhanced by disturbance by livestock and rabbits. Exotic plants influence the vegetation communities directly by their presence, and indirectly through competition with

Table 5. Soil surface variables and their distribution across the six Map Units.

Variables which changed little across the sites have been excluded. The modal (most common) value is in the first row, and the range of values, recorded for each Map Unit, in the second; 100+ for litter cover indicates 100% cover but several cm thick; mod. = moderately.

Map Unit	Texture	Crust coherence	Firmness	Microtopography (mm)	Cryptogam cover (%)	Soil cover (%)	Basal cover (%)	Litter cover (%)
1	**sand**	**easily broken**	**mod. firm**	**3 to 8**	**< 1**	**1 to 15**	**< 7**	**50 to 75**
	(sand to loam)	(sand to very hard)	(mod. firm to firm)	(< 3 to 100)	(< 1 to 50)	(< 1 to > 50)	(< 7 to 140)	(< 10 to 100)
2	**sandy loam**	**easily broken**	**mod. firm**	**8 to 25**	**< 1**	**1 to 15**	**< 7**	**25 to 50**
	(sand to sandy loam)	(sand to very hard)	(mod. firm to firm)	(< 3 to 100)	(< 1 to > 50)	(< 1 to > 50)	(< 7 to > 140)	(< 10 to 75)
3	**sandy loam**	**easily broken**	**mod. firm**	**3 to 8**	**< 1**	**15 to 30**	**7 to 70**	**10 to 25**
	(sand to sandy loam)	(sand to self mulching)	(mod. firm to firm)	(< 3 to 25)	(< 1 to 10)	(1 to > 50)	(< 7 to 140)	(10 to 75)
6	**loam**	**easily broken**	**firm**	**3 to 8**	**< 1**	**15 to 30**	**7 to 70**	**25 to 50**
	(sandy loam to clay loam)	(easily broken to self mulching)	(mod. firm to firm)	(< 3 to 100)	(< 1 to > 50)	(< 1 to > 50)	(< 7 to 140)	(< 10 to 100)
4	**clay loam**	**self-mulching**	**firm**	**8 to 25**	**1 to 10**	**30 to 50**	**< 7**	**25 to 50**
	(loam to clay)	(very hard to self mulching)	(firm)	(3 to 100)	(< 1 to 50)	(1 to 50)	(< 7 to 70)	(10 to 50)
5	**loam**	**easily broken**	**firm**	**8 to 25**	**10 to 50**	**1 to 15**	**< 7**	**25 to 50**
	(sandy loam to loam)	(easily broken to self mulching)	(mod. firm to firm)	(< 3 to 25)	(< 1 to > 50)	(< 1 to 50)	(< 7 to 70)	(< 10 to 100+)

Table 6. Differences in electrical conductivity (EC), organic carbon (OC) and pH between the six Map Units

	Map Units (number of sites)						
Variables	**1 (30)**	**2 (34)**	**3 (16)**	**6 (18)**	**4 (12)**	**5 (10)**	**Total (120)**
EC (dS m^{-1})	0.08 (0.02)^{ab}	0.06 (0.01)^{ab}	0.06 (0.01)^{ab}	0.15 (0.04)^{bc}	0.12 (0.01)^{bc}	0.09 (0.02)^{abc}	0.09 (0.01)
OC (%)	1.04 (0.11)^{a}	1.01 (0.07)^{a}	0.76 (0.04)^{a}	1.31 (0.17)^{a}	1.98 (0.11)^{b}	3.16 (0.70)^{c}	1.31 (0.09)
pH	6.45 (0.09)^{a}	6.36 (0.04)^{a}	6.43 (0.09)^{a}	6.27 (0.10)^{a}	6.21 (0.09)^{a}	6.42 (0.04)^{a}	6.37 (0.03)

Standard error of the mean is in parentheses. Values within a row with a similar superscript are not significantly different at $P = 0.05$. Electrical conductivity data were $\log_{10}$ transformed prior to ANOVA.

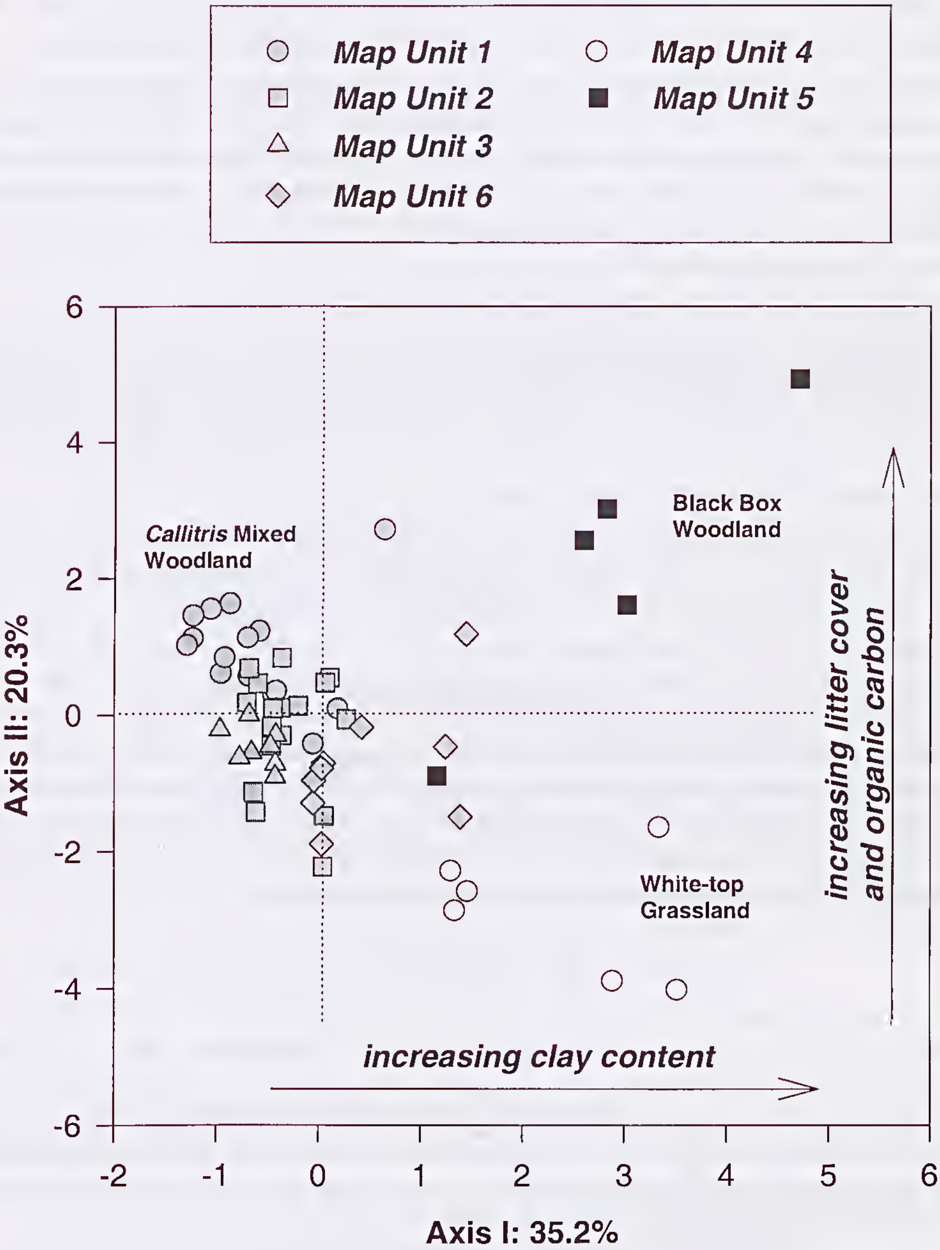

Fig. 8. Projection of the sample sites onto axes I and II of the species-environment biplot.

native species (McIntyre 1990). *Lycium ferocissimum* for example, poses a major threat to the exclosure through its capacity to rapidly invade, colonise and reproduce. *Lycium ferocissimum* provides a harbour for rabbits, and, as the seeds are readily eaten and dispersed by birds, it is present in most areas of the exclosure and dispersal is not restricted by fencing (Appendix 1). Physical removal, combined with the judicious use of herbicides and fire, appears to be an ecologically desirable control option.

Of greater concern in the long-term is the spread of exotic forbs and grasses which are more difficult to control. It is probable that forbs such as *Marrubium vulgare*, *Heliotropum* spp. and *Tribulus terrestris*, as well as the annual grasses *Avena* spp., *Lolium* spp. and *Bromus* spp. will prove a greater challenge for managers. Large areas of the Riverine Plain have already been invaded by exotic forbs and grasses, and their control in the exclosure is likely to be ongoing.

Since the construction of the exclosure in 1997, the Southern Riverina Naturalists have undertaken a rabbit control program using 1080 poison baits in conjunction with the ripping of warrens. As the regeneration of *Alectryon oleifolius* subsp. *canescens* is limited, and the regeneration of *Callitris glaucophylla* is rarely seen in the presence of rabbits or livestock, ongoing rabbit control is essential. Monitoring of rabbit warrens and regular examination of the fencing is recommended.

Control of wildfire has been identified as a contentious issue in the management of the 'Zara' exclosure. It is apparent from the present survey and anecdotal evidence, that the cover and density of shrubs such as *Rhagodia spinescens, Atriplex nummularia* and *Enchylaena tomentosa* have increased markedly over the past few decades and will continue to increase given the removal of stock. This may be associated with reductions in ground cover of perennial grasses and a reduced risk of wildfire. In the absence of controlled burning, large areas of the exclosure, particularly in the *Callitris* Mixed Woodland are likely to be converted from a grassland to a chenopod-dominated shrubland. One of the benefits of shrub increase is that the exclosure now provides a regular local seed source of native shrubs. These are collected and used extensively by Greening Australia in revegetation programs.

Conservation significance of the 'Zara' exclosure

The 'Zara' exclosure is an important example of the *Callitris* Mixed Woodlands which were once more common on aeolian landscapes on the Riverine Plain. Today this vegetation community is poorly conserved, threatened or vulnerable, due to inappropriate land use practices (Benson 1988, 1989, 1991, Eardley 1999). The *Callitris* Mixed Woodland at 'Zara' has a healthy understorey, and unlike many sandhills in the area, the community has retained part of its original shrub component (including *Atriplex nummularia* in Map Units 2 and 3).

Although not found in the present study, one ROTAP species *Ptilotus extenuatus* (Appendix 1, Briggs & Leigh 1996) was collected from the exclosure. *Ptilotus extenuatus* is now the only plant species presumed to be extinct on the Hay Plain, and despite numerous attempt to locate other specimens (Briggs & Leigh 1996) the species has not been recorded. *Calotis moorei*, a Schedule 1 species under the

Threatened Species Conservation Act was also collected at 'Zara' in the early 1900s (Short 1991). Additional species may be collected in the future following the exclusion of domestic and feral grazing animals.

The future of the 'Zara' exclosure

The present study provides a basis for future management strategies for sandhill remnants and monitoring programs. Being close to a large population centre (Deniliquin), the exclosure could serve as a focal point for community groups interested in learning more about semi-arid vegetation communities. Permanent sample points, already in place, can provide an invaluable baseline for future soil and ecological studies, and regular updating of the species lists by members of the Riverina Field Naturalists. The reserve can also provide ungrazed, benchmark sites to be incorporated into the Department of Land and Water Conservation's Rangeland Assessment Program. Future studies in the exclosure could include an examination of small mammal populations in relation to vegetation communities, temporal changes in plant communities after exclosure and recruitment of *Callitris glaucophylla* and *Alectryon oleifolius* after removal of sheep, rabbits and noxious shrubs.

The exclosure has the potential to complement other remnants and more formal conservation practices within the Riverina Bioregion (Eardley 1999). However, for it to be successful in the long term, it is important that it be incorporated into any future Land and Water Management Plans and Regional Conservation Plans for the area.

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Appendix 1: Species recorded for the 'Zara' enclosure, and the percentage of sites containing a particular speices within each of the six Map Units.

A = Mulham (unpub.); B = present study; + = species found; - = species not found; * = exotics; ! = ROTAP species; z = recorded by Short (1991).

Botanical Name	**A**	**B**	**Map Unit (No. of sites)**						
			1 (15)	**2 (17)**	**3 (8)**	**6 (9)**	**4 (6)**	**5 (5)**	**Total (60)**
PTERIDOPHYTES									
Adiantaceae									
Cheilanthes austrotenuifolia	+	+	.	6	.	.	.	.	2
Marsileaceae									
Marsilea drummondii	-	+	.	.	.	11	.	20	3
GYMNOPERMS									
Cupressaceae									
Callitris glaucophylla	+	+	80	29	25	.	.	.	32
ANGIOSPERMS-DICOTYLEDONS									
Aizoaceae									
**Mesembryanthemum crystallinum*	+	+	93	100	88	.	.	.	63
Amaranthaceae									
Alternanthera denticulata	+	-							
!Ptilotus extenuatus	+	-							
Apiaceae									
Daucus glochidiatus	+	-							
Asteraceae									
Actinobole uliginosum	+	+	13	12	.	.	.	.	7
**Arctotheca calendula*	+	-							
**Aster subulatus*	+	-							
Brachycome lineariloba	-	+	.	6	.	.	.	.	2
Calotis sp.	-	+	7	.	.	.	.	.	2
Calotis erinacea	+	-							
^{z}*Calotis moorei*	-	-							
Calotis scabiosifolia	+	-							
Calotis scapigera	+	-							
**Carthamus lanatus*	+	-							
**Centaurea melitensis*	+	-							
Centipeda cunninghamii	+	-							
Chrysocephalum apiculatum	+	-							
**Chrysocephalum semipapposum*	+	-							
**Cirsium vulgare*	+	-							
**Cotula bipinnata*	+	-							
Eriochlamys behrii	-	+	.	.	.	.	.	20	2
**Hypochaeris glabra*	+	-							
Pseudognaphalium luteoalbum	+	-							
Senecio quadridentatus	+	+	13	.	.	.	.	20	5
**Sonchus oleraceus*	+	-							
Stuartina muelleri	+	-							
Vittadinia cuneata group	+	+	7	6	.	11	.	.	5
**Xanthium spinosum*	+	-							
Boraginaceae									
**Amsinckia intermedia*	+	+	13	.	13	.	.	.	5
**Echium plantagineum*	+	+	27	71	100	56	67	.	55
**Heliotropium europaeum*	+	+	7	12	.	11	.	.	7

Botanical Name	**A**	**B**	**Map Unit (No. of sites)**						
			1 (15)	**2 (17)**	**3 (8)**	**6 (9)**	**4 (6)**	**5 (5)**	**Total (60)**
Brassicaceae									
**Capsella bursa-pastoris*	+	-							
**Lepidium africanum*	-	+	60	29	63	67	.	60	47
**Sisymbrium erysimoides*	+	+	67	35	.	22	.	20	32
**Sisymbrium orientale*	+	-							
Campanulaceae									
Wahlenbergia sp.	+	+	7	12	.	.	.	.	5
Caryophyllaceae									
**Cerastium glomeratum*	+	-							
**Spergularia rubra*	+	+	.	.	.	.	.	20	2
Chenopodiaceae									
Atriplex leptocarpa	+	+	.	6	.	22	17	.	7
Atriplex nummularia	+	+	13	41	63	11	.	20	27
Atriplex pseudocampanulata	-	+	.	.	.	.	.	20	2
Atriplex semibaccata	+	+	.	.	.	22	50	20	10
Atriplex vesicaria	+	-							
Chenopodium nitrariaceum	+	+	.	6	13	22	.	20	8
Chenopodium pumilio	-	+	7	12	13	22	.	.	10
Einadia nutans	+	+	33	24	13	.	17	60	23
Enchylaena tomentosa	+	+	67	82	75	67	83	80	75
Maireana aphylla	+	+	.	.	.	.	33	.	3
Maireana decalvans	+	+	.	.	.	11	33	20	7
Maireana pentagona	+	+	7	6	.	.	100	40	17
Rhagodia spinescens	+	+	93	100	100	100	83	100	97
Salsola kali	+	+	7	41	.	33	.	20	20
Sclerolaena diacantha	-	+	.	6	.	.	.	.	2
Sclerolaena muricata	-	+	.	6	.	22	33	20	10
Convolvulaceae									
Convolvulus erubescens	+	+	7	6	.	11	.	.	5
Crassulaceae									
Crassula colorata var. *acuminata*	+	+	27	.	.	11	.	.	8
Cucurbitaceae									
**Citrullus lanatus* var. *lanatus*	+	+	20	18	13	11	.	.	13
Euphorbiaceae									
Chamaesyce drummondii	+	-							
Fabaceae-Caesalpinoideae									
Senna artemisioides	-	+	13	.	.	11	.	.	5
Senna artemisioides subsp. *coriacea*	+	-							
Senna artemisioides subsp. *filifolia*	+	-							
Fabaceae-Faboideae									
**Medicago polymorpha*	+	-							
**Medicago truncatula*	+	-							
Swainsona phacoides	+	-							
**Trifolium angustifolium*	+	-							
**Trifolium arvense*	+	+	20	47	100	44	.	20	40
Fabaceae-Mimosoideae									
Acacia oswaldii	+	+	.	.	25	11	.	20	7
Acacia pendula	+	+	.	.	.	.	17		2
Acacia salicina	+	+	20	.	38	22	.	20	15

Botanical Name	**A**	**B**	**Map Unit (No. of sites)**						
			1 (15)	**2 (17)**	**3 (8)**	**6 (9)**	**4 (6)**	**5 (5)**	**Total (60)**
Geraniaceae									
**Erodium cicutarium*	+	-							
Erodium crinitum	+	-							
Goodeniaceae									
Goodenia fascicularis	+	-							
Goodenia pinnatifida	+	-							
Goodenia pusilliflora	+	-							
Lamiaceae									
**Marrubium vulgare*	+	+	7	.	.	.	.	.	2
Teucrium racemosum	+	+	.	.	.	11	.	20	3
Loranthaceae									
Amyema quandang	+	-							
Lysiana exocarpi subsp. *exocarpi*	+	-							
Malvaceae									
**Malva parviflora*	+	-							
Sida corrugata	+	+	7	.	.	33	33	20	12
Myoporaceae									
Eremophila longifolia	+	+	27	47	88	44	17	20	42
Myoporum montanum	+	-							
Myoporum platycarpum	+	+	7	6	.	.	.	.	3
Myrtaceae									
Eucalyptus largiflorens	+	+	7	6	.	11	.	100	13
Eucalyptus largiflorens x populnea	+	-							
Nyctaginaceae									
Boerhavia coccinea	+	+	7	6	38	.	17	.	10
Oleaceae									
Jasminum lineare	+	+	53	12	63	11	.	20	28
Oxalidaceae									
Oxalis perennans	+	+	.	6	.	11	17	20	7
Pittosporaceae									
Bursaria spinosa subsp. *microphylla*	+	+	20	6	25	11	.	.	12
Pittosporum phylliraeoides	+	-							
Plantaginaceae									
Plantago sp.	+	-							
Polygonaceae									
Muehlenbeckia florulenta	+	-							
**Polygonum aviculare*	+	-							
Portulacaceae									
Calandrinia eremaea	+	-							
Portulaca oleracea	+	-							
Proteaceae									
Hakea leucoptera	+	-							
Hakea tephrosperma	+	+	60	35	13	33	.	.	32
Ranunculaceae									
Clematis microphylla var. *microphylla*	-	+	20	.	50	.	.	.	12
**Myosurus minimus*	+	-							
Ranunculus pentandrus	+	-							
Ranunculus pumilio	+	-							
Rubiaceae									
Asperula conferta	+	-							

Botanical Name	**A**	**B**	**Map Unit (No. of sites)**						
			1 (15)	**2 (17)**	**3 (8)**	**6 (9)**	**4 (6)**	**5 (5)**	**Total (60)**
Santalaceae									
Exocarpos aphyllus	+	+	73	59	50	33	.	80	53
Santalum acuminatum	+	+	20	.	.	.	.	.	5
Santalum lanceolatum	+	+	20	6	38	.	.	.	12
Sapindaceae									
Alectryon oleifolius subsp. *canescens*	+	+	53	29	13	.	.	.	23
Dodonaea viscosa subsp. *angustissima*	+	+	80	59	75	33	.	.	52
Solanaceae									
**Lycium ferocissimum*	+	+	60	59	38	44	.	80	50
Solanum esuriale	-	+	.	.	.	22	17	.	5
**Solanum nigrum*	-	+	7	.	.	.	.	.	2
Thymelaeceae									
Pimelea microcephala subsp. *microcephala*	+	+	7	6	.	11	.	.	5
Urticaceae									
**Urtica urens*	+	-							
Zygophyllaceae									
Nitraria billardieri	+	-							
**Tribulus terrestris*	-	+	7	6	13	.	.	.	5
ANGIOSPERMS-MONOCOTYLEDONS									
Cyperaceae									
Carex inversa	+	-							
**Cyperus eragrostis*	+	+	.	.	.	11	17	40	7
Eleocharis acuta	+	-							
Phormiaceae									
Dianella longifolia	+	+	.	6	.	.	.	.	2
Poaceae									
Agrostis avenacea var. *avenacea*	+	+	7	.	.	.	.	.	2
**Alopecurus geniculatus*	+	-							
**Avena fatua*	+	+	7	6	25	.	33	.	10
Bromus arenarius	+	+	87	88	100	78	17	20	75
**Bromus diandrus*	+	-							
**Bromus rubens*	+	-							
Chloris truncata	+	-							
Cynodon dactylon	+	-							
Dactyloctenium radulans	+	-							
Notodanthonia caespitosa	+	+	13	65	38	89	100	100	58
Elymus scaber var. *scaber*	-	+	.	.	.	11	50	40	10
Enneapogon nigricans	+	-							
Enteropogon acicularis	+	+	7	94	38	89	83	60	60
Eragrostis australasica	+	-							
**Eragrostis cilianensis*	+	-							
**Hordeum leporinum*	+	+	33	12	.	22	33	.	18
**Hordeum marinum*	+	-							
**Lolium rigidum*	+	+	.	.	.	.	50	.	5
Paspalidium constrictum	+	-							
**Schismus barbatus*	+	+	33	18	38	11	.	20	22
Sporobolus caroli	+	+	.	6	.	.	.	.	2
Stipa elegantissima	+	+	60	65	88	33	.	60	55
Stipa sp.	+	+	87	100	100	78	67	20	83
**Vulpia myuros*	+	+	73	12	88	89	17	.	48
Total no. of species	**129**	**77**	**54**	**51**	**35**	**46**	**26**	**36**	**77**

Appendix 2: Species names and codes (in alphabetical order) used in the cluster analysis and the Canonical Correspondence Analysis. * indicates an exotic species.

Code	Species
Aksa	*Acacia salicina*
Atnm	*Atriplex nummularia*
Atsm	*Atriplex semibaccata*
Avnf	**Avena fatua*
Bhvc	*Boerhavia coccinea*
Bmar	*Bromus arenarius*
Brss	*Bursaria spinosa* subsp. *microphylla*
Cazz	*Calotis* sp.
Chla	*Cheilanthes austrotenuifolia*
Ctrl	**Citrullus lanatus* var. *lanatus*
Dacp	*Notodanthonia caespitosa*
Ddat	*Dodonaea viscosa* subsp. *angustissima*
Ehlt	*Enchylaena tomentosa*
Ekmp	**Echium plantagineum*
Elms	*Elymus scaber* var. *scaber*
Emlg	*Eremophila longifolia*
Etpa	*Enteropogon acicularis*
Exoa	*Exocarpos aphyllus*
Hkts	*Hakea tephrosperma*
Hodl	**Hordeum leporinum*
Jsml	*Jasminum lineare*
Kltg	*Callitris glaucophylla*
Kppm	*Chenopodium pumilio*
Lcmf	**Lycium ferocissimum*
Leaf	**Lepidium africanum*
Mapg	*Maireana pentagona*
Msbc	**Mesembryanthemum crystallinum*
Oleo	*Alectryon oleifolius*
Rgsp	*Rhagodia spinescens*
Sacg	*Sida corrugata*
Sbme	**Sisymbrium erysimoides*
Semz	*Sclerolaena muricata*
Shsb	**Schismus barbatus*
Sieg	*Stipa elegantissima*
Sizz	*Stipa* sp.
Slml	*Santalum lanceolatum*
Slsk	*Salsola kali*
Tmav	**Trifolium arvense*
Uklf	*Eucalyptus largiflorens*
Vlpm	**Vulpia myuros*

Vegetation of the Guyra 1: 100 000 map sheet New England Bioregion, New South Wales

J.S. Benson and E.M. Ashby

Benson, J.S. and Ashby, E.M. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 2000. The natural vegetation of the Guyra 1: 100 000 map sheet, New England Bioregion, New South Wales. Cunninghamia *6(3): 747–872.* The remnant natural vegetation (excluding native grasslands) of the Guyra 1: 100 000 map sheet area was sampled by way of 312 20 m × 20 m plots in which all vascular species were recorded using a modified Braun-Blanquet abundance rating. Sampling was stratified to cover the environmental factors of substrate, topographic position and altitude. Floristic analyses used the Kulczynski coefficient of dissimilarity in an agglomerative hierarchical cluster analysis and multidimensional scaling ordinations. Twenty-one plant communities were selected from the cluster analysis. The contribution of species to these groupings was investigated using a fidelity analysis. Another three communities were distinguished from aerial photographs and field traverse. These 24 plant communities are described and all except riparian vegetation are mapped. Their extent was mapped using aerial photography and ground traverses. The vegetation map was digitised at a scale of 1: 25 000 but has been reduced to 1: 100 000 for this publication. The minimum area mapped is 1 ha.

Eight hundred and eighty-nine plant taxa are reported for the study area, 681 of which were recorded during the survey. Common families are Poaceae, Asteraceae, Fabaceae, Myrtaceae, Orchidaceae and Cyperaceae. The status of the 28 nationally or State listed rare or threatened plant species, and other regionally rare species recorded in the area, is discussed. Some plant communities, such as those dominated by the stringybarks *Eucalyptus caliginosa* and *Eucalyptus laevopinea*, are ubiquitous in the landscape. Other communities are restricted in their geographic extent and contain a distinct suite of species. These included heath swamps, some forests on leucogranite and wetland vegetation in lagoons on basalt plateaux. 74% of the native woody vegetation has been cleared. This has particularly affected plant communities on higher nutrient soils including *Eucalyptus viminalis* and *Eucalyptus dalrympleana* subsp. *heptantha* open forest on basalt plateaux, *Eucalyptus nova-anglica* woodland in valleys, and *Eucalyptus blakelyi* and *Eucalyptus melliodora* woodland on sediments at lower altitudes. Most of the remnants have been grazed by stock thus influencing the understorey structure and species composition. Upright forbs and *Acacia* would appear to be less common now than prior to European settlement. Dieback of eucalypts over the last two decades has compounded the impacts of clearing. Logging and firewood cutting affects some plant communities. Weeds are most invasive where understorey disturbance is greatest, which is mainly in the small remnants on higher nutrient soil (basalt and sediments). Most of the lagoons in the study area have been drained or impounded, thus depleting wetland vegetation. Changes to fire regimes in the forest remnants may also have altered the populations of fire-dependent species. Most of the plant communities are poorly represented in conservation reserves. Conservation initiatives on private land are required to protect most of the communities. Key sites for conservation are listed.

Introduction

Approximately 60% of the woody vegetation in the New England bioregion of New South Wales has been cleared (Pressey et al. in press, Benson 1999). The Guyra 1: 100 000 map sheet is typical: more than 70% of the map sheet area has been cleared, but in a patchy way (Fig. 1). McIntyre and Barrett (1992) coined the term 'variegated landscape' to describe the New England countryside as it is composed of numerous patches of forest interspersed with cleared grazing country. Higher nutrient soils derived from basalt or alluviums have been most cleared, whereas large areas of vegetation growing on low nutrient soils derived from leucogranite in the region remain intact. Most of the understorey of forest remnants on private land have been extensively grazed over the last 130 years.

The aim of this project was to sample, document and map the extant native vegetation of the Guyra 1: 100 000 map sheet in the New England Bioregion. This will form a nucleus for further survey and mapping of the bioregion. This work concentrated on documenting the eucalypt-dominated open forests and woodlands (Walker & Hopkins 1990). We also surveyed and mapped shrublands, sedgelands and wetlands but did not survey or map natural or derived (Benson 1996) native grasslands. This work could be used to produce a pre-European vegetation map through further field survey and modelling (using methodology similar to that in Ferrier and Watson 1997 for example). However, by examining clearing patterns in the landscape, we provide estimates for the percentage remaining of each classified plant community.

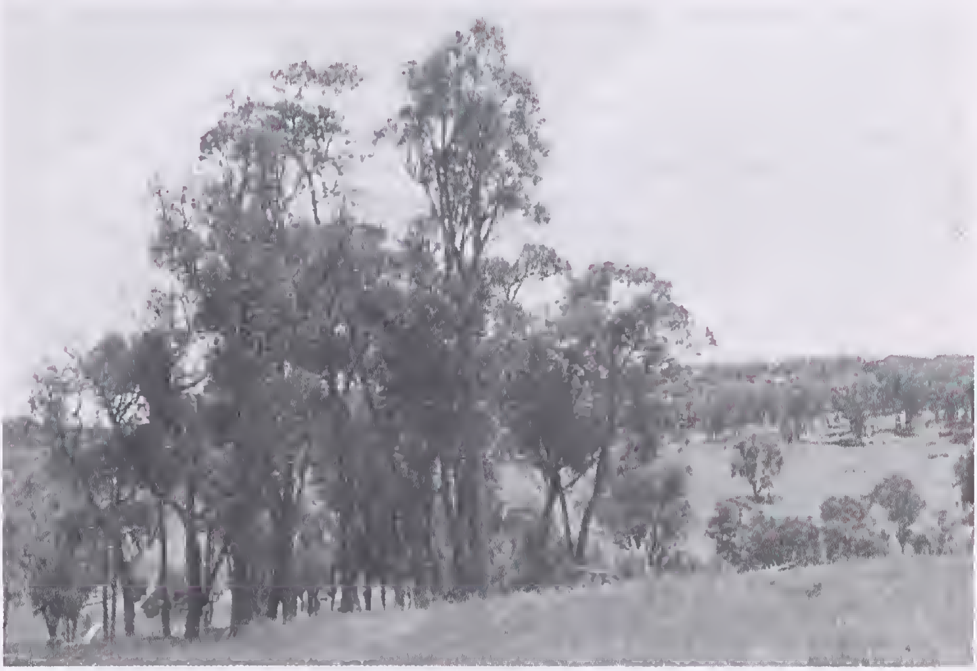

Fig. 1. The New England Tableland Bioregion contains patches of forest of varying sizes scattered across a mainly cleared landscape.

The floristic data collected during this survey, along with the 1: 100 000 vegetation map (located inside the back cover) and the 1: 25 000 vegetation maps held on the geographic information system at the National Herbarium, will assist with land use planning in the study area. The data are particularly relevant for use in developing a regional vegetation plan under the Native Vegetation Conservation Act 1998.

Study area

The study area is defined by the Guyra 1: 100 000 map sheet (number 9237) on the Northern Tablelands (NT) botanical subdivision (Anderson 1961) of NSW (Fig. 2). It is located in the middle of the New England Bioregion (NEB) defined in Thackway and Cresswell (1995). Both regions are referred to in this paper. The main difference in the area covered by NT compared to NEB is that it includes western appendages along the Warrumbungle and Nandewar Ranges.

The Guyra map sheet is bounded by latitudes 30°30'S and 30°00'S and longitudes 151^0 30'E and 152°00'E. The study area occupies approximately 2500 sq km and is bisected by the New England Highway running north-south along the Great Dividing Range. It is mainly within the Dumaresq and Guyra Shires with small proportions in the Uralla and Severn Shires. The area includes some of the higher parts of the Northern Tablelands of New South Wales. The town of Guyra is located centrally on a high basalt plateau, at the intersection of the New England Highway and the Ebor-Tingha roads. The northern part of the city of Armidale is on the southern boundary of the map area.

The study area contains some of the upper catchments of the eastern flowing Aberfoyle, Oban, Henry, Sara, Wollomombi and Gara rivers, and the western flowing Gwydir and McIntyre rivers. Altitudes range from 900 m in the south-east to above 1500 m on the Ben Lomond Range in the north.

The majority of the area is private land which is used principally for pastoralism. The more fertile, flat areas have been extensively cleared of native vegetation and native pastures have progressively been replaced with introduced pasture species that are reliant on fertilizers. Cropping is limited in extent due to the cold climate. There is increasing urbanisation of rural holdings closer to Armidale.

There are five conservation reserves totalling 1904 ha managed by the NSW National Parks and Wildlife Service. These cover only 0.72% of the study area. Parts of two small state forests (Armidale State Forest 230 ha and Avondale SF 220 ha) are also present, however Armidale State Forest is mostly a pine plantation.

Climate

The climate of the New England region is described in Hobbs and Jackson (1977). The region receives cold westerly or southwesterly winds in winter and mainly mild easterly winds in summer. Rain-bearing easterly winds, occasional cyclonic depressions and thunderstorms deliver maximum rainfall for the region in late spring and summer (Fig. 3). Some of this rain is high intensity, thus presenting an erosion hazard. Low pressure systems and cold fronts bring rain and occasionally snow in winter, peaking in June. Regions at higher elevations receive higher rainfall in the study area. For example, Ben Lomond at 1360 m asl, receives an average of 1083 mm pa compared to Wandsworth at 1100 m asl which receives 827 mm and Armidale at 1000 m asl which receives 789 mm (Bureau of Meteorology 1996). A rainshadow exists in the valleys east of Armidale, including in the valley of the Wollomombi River that flows into the relatively dry Macleay gorges. Orographic factors increase precipitation on the ranges in the study area (such as Days Ridge and Mount Duval) that are exposed to moist easterly airstreams in summer.

Temperatures are warm in summer and cold in winter (Fig. 3). Summer temperatures are milder and winter temperatures colder than at locations at lower elevations

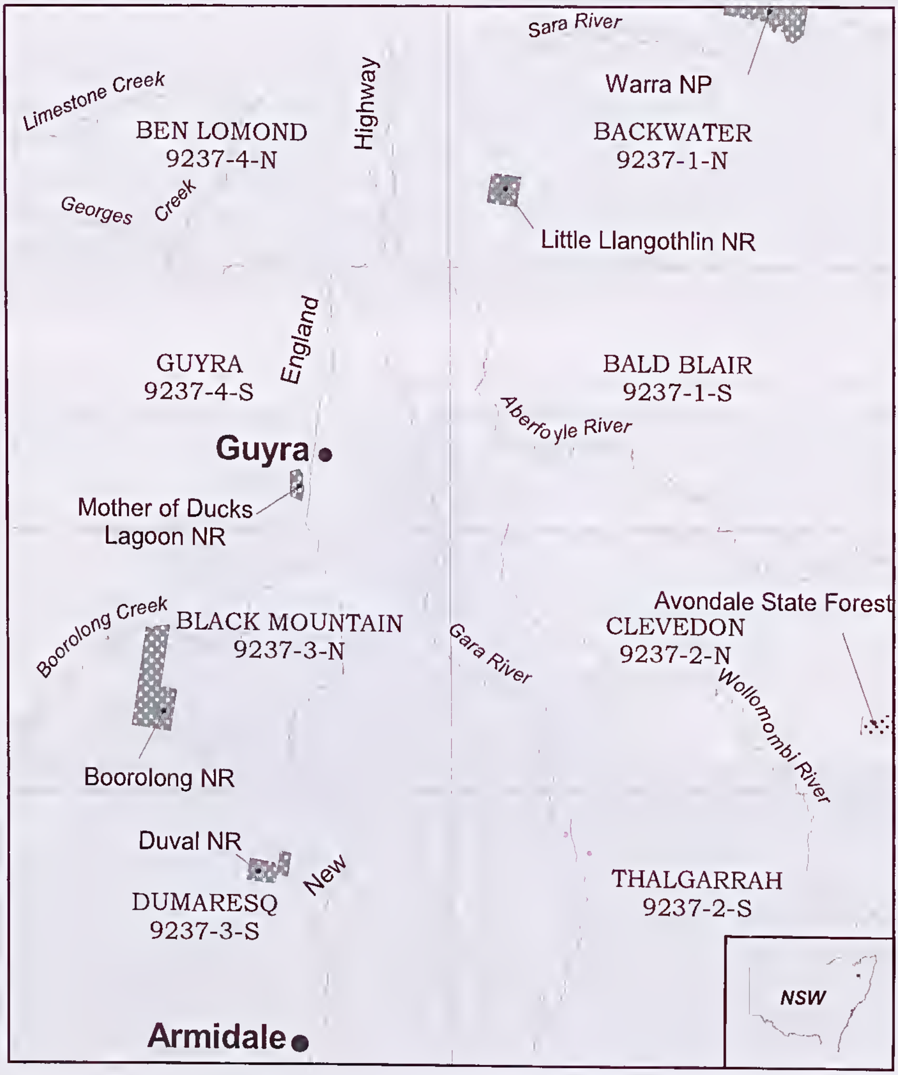

Fig. 2. Location of the Guyra 1: 100 000 map sheet, showing major rivers, conservation reserves, towns and the eight 1: 25 000 topographic maps that cover the area.

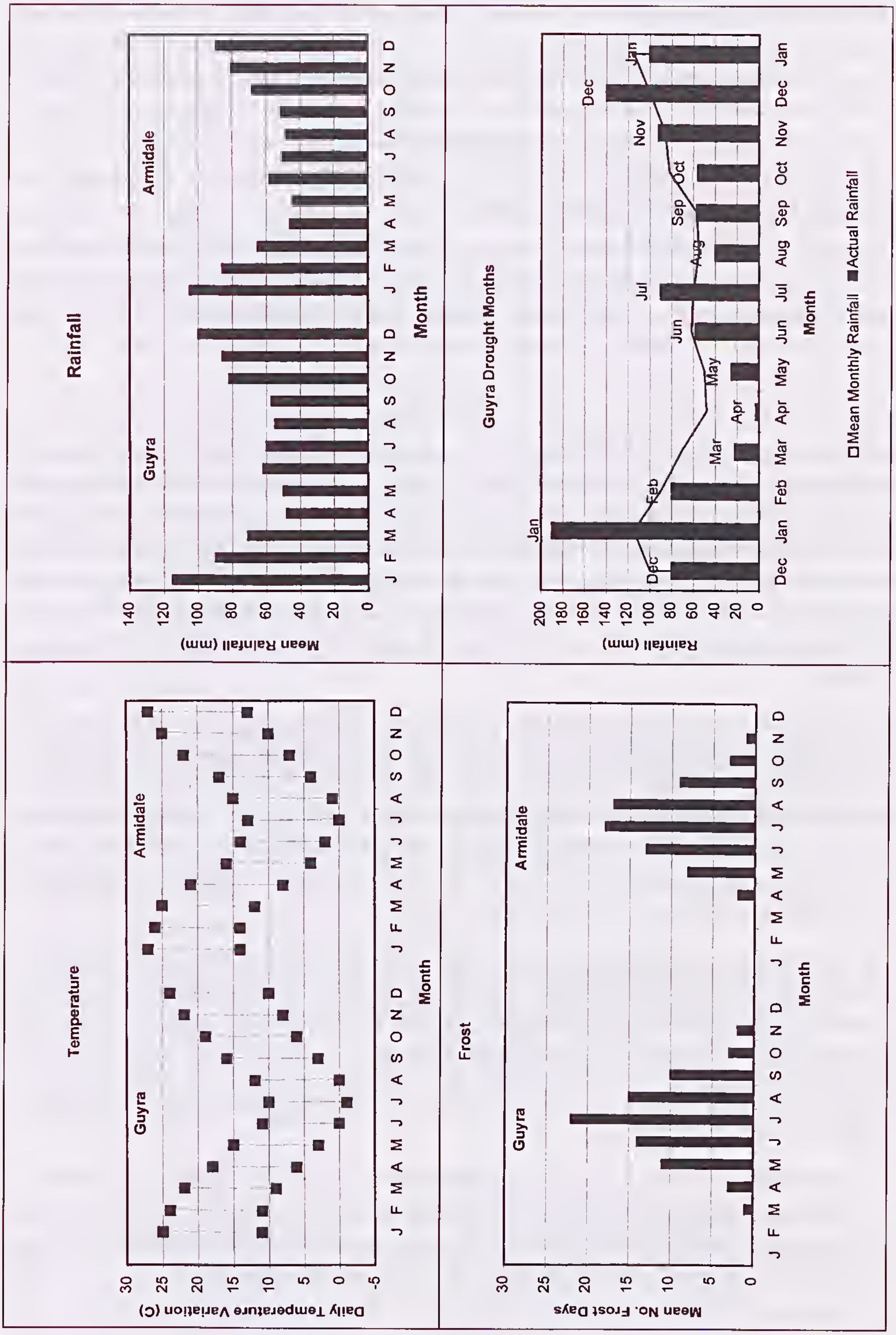

Fig. 3. Climate features of the towns of Guyra and Armidale including average monthly temperature, rainfall and frost days. Drought months for Guyra are shown for the period of field sampling, December 1992 to January 1994, by comparing the mean annual rainfall with actual rainfall for that period.

outside the study area on the Northern Tablelands or in adjoining regions. The high basalt plateau around Guyra is colder than lower parts such as Armidale. The latter has an average maximum summer temperature in January of 27°C compared to Guyra 24°C. Both have cold winters with an average minimum temperature in July of approximately zero. Frosts are common with an average of 20 frost days in Guyra and 17 in Armidale in July (Fig. 3). Cold air drainage affects most river valleys and hence the type of vegetation that occurs there.

Drought is less common on the tablelands than further west. The survey coincided with drought in eastern Australia and the study area was drought declared for 11 of the 14 months of the study period. During 1993, monthly rainfall fell below the average for nine out of the 12 months (Fig. 3).

Geology

The geology of the Northern Tablelands and adjoining coastal regions is depicted on the Dorrigo-Coffs Harbour 1: 250 000 geological map (NSW Department of Mines 1969). The Guyra 1: 100 000 map sheet is represented on the north-west corner of this map. Binns (1967) provides a summary of the geology and a geological map at 1: 250 000 scale covering the southern part of the New England Tableland including the Guyra region. A more accurate and detailed geological map covering the Guyra map sheet has been produced at a scale of 1: 100 000 by the NSW Department of Mineral Resources (1988).

The dominant structural feature of the Northern Tablelands is the New England Fold Belt, composed of a number of blocks of Paleozoic rocks including the New England Block (Harrington 1977, Rod 1974). These stratified rocks have been intensely folded and the strike line tends to follow the orientation of the major faults in the region, north to north west. A number of plutonic intrusions from the same era are present. Basalts from the Tertiary period overlay these rocks in parts of the region, particularly on the plateau between Guyra and Glen Innes.

In general, low elevations of the study area are composed of sedimentary or metamorphic rocks, while higher elevations tend to be composed of a range of granites, leucoadamellites (leucogranites) and Tertiary basalts. Acid volcanic rocks outcrop mainly west of the Great Dividing Range.

The Guyra 1: 100 000 geology map (Department of Mineral Resources 1988) shows the following main rock types:

- Metasediments of the Devonian Sandon Beds composed of lithic wacke, slate and chert cover much of the southern and south-western section of the study area;
- Devonian Uralla plutonic suite including the Mount Duval adamellite, Boorolong adamellite, Aberfoyle River porphyry and Llangothlin adamellite;
- Devonian and Permian leucadamellites in the Backwater-Oban River areas;
- Permian felsic volcanics (acid volcanics) in the north-western section of the area;
- Tertiary basalts on the plateau centred on Guyra and Ben Lomond, with outlying outcrops scattered over much of the rest of the area;
- Quaternary alluvials along rivers and in swamps.

A simplified geology map containing seven classes of substrate was developed by the National Parks and Wildlife Service in consultation with the NSW Geological Survey. This was used as one factor in stratifying the sampling of the vegetation of the study area.

Geomorphology

The Great Dividing Range runs north-south through the centre of the study area. It contains the upper catchments of both easterly and westerly-flowing river systems. Most of the landscape is undulating plateau broken by a number of higher ridges such as Mount Duval, Days Ridge and Mount Hourigan. An escarpment is present at the Devils Pinch separating the basalt plateau to the north from the Dumaresq Valley, mainly composed of sedimentary rocks, to the south.

On the top of the range on the basaltic plateau, the relief is small and the altitude high (up to 1509 m in the north at The Brothers). Lagoons are present in depressions on this plateau. More dissected country is found on the edge of the plateau where drainage lines have eroded the granites and leucogranites to the north east, the sediments and the granites of the south, and the acid volcanic rocks of the north-west. The altitude is still high in the valleys — down to a minimum of only 900 m along the Gara River in the south east. The most complex terrain is present on the leucogranite in the Backwater region where steep, rocky ridges are separated by valley flats, swamps and creek-lines.

The study area includes sections of five of the land provinces described by Morgan and Terrey (1990):

- Glen Innes-Guyra Basalts: occupying the central part of the study area, composed of rich soils on flat terrain at altitudes 1200–1500 m which has mostly been cleared;
- Armidale Plateau: in the south of the study area, mainly composed of sedimentary substrates of medium fertility at altitudes 900–1200 m;
- Wongwibinda Plateau: covering the south-eastern part of the area composed of sediments and basalts between 900–1100 m;
- Moredun Volcanics: in the north-western section of the area composed of acid volcanics and siliceous sedimentary substrates at altitudes 1000–1200 m;
- Nightcap Province: in the north-eastern section of the area mainly composed of leucogranites and granites with low soil fertility and hence containing the largest remnants of native vegetation.

Soils

Detailed descriptions of the soils of the New England Region, including the study area, are described and mapped in Jessup (1965), while Morgan and Terrey (1990) described soils of their land provinces on the New England Tableland.

The main soil associations in the study area are:

- Yellow podzolics and solodic soils, minor red earths and siliceous sands on sedimentary and metamorphic substrates in the vicinity of Armidale, Aberfoyle River and scattered localities elsewhere;

- Chocolate soils and krasnozems on ridges and weisenbodens in valleys on the basalt plateau at Guyra;
- Yellow sodolics on lower slopes and yellow podzolics on upper slopes on acid volcanics west of Guyra;
- Sandy yellow podzolics and gley podzolics on granites east of Llangothlin;
- Siliceous sands on upper slopes with gleyed podzolics in swamps on leucogranites near Backwater.

Gleyed solodic soils have a mottled B horizon with ironstone nodules in the A horizon. Podzolic soils have a contrast in texture with sharp boundaries between A and B horizons. Both solodic and podzolic soils are usually clayey. Chocolate soils on basalt are clayey with a mottled B horizon. Krasnozem soils on basalt are loamy gradational, reddish and well structured.

Land use history

Aboriginal occupation

At the time of European settlement the Anaiwan Tribe occupied much of the Northern Tablelands. Remaining physical evidence of these people's use of the Northern Tablelands includes rock shelters, camp sites, burials, ceremonial grounds, stone axes, axe grinding grooves (nearest at Tingha west of the study area) and art sites mainly under granite overhangs (Connah et al. 1977).

Aboriginal people lived in this area from at least 3000 B.C. This date is late compared to other regions of south-eastern Australia, either due to the cold post-ice age climate or because evidence of earlier occupation is lacking. It is likely that the cold, higher regions such as Guyra were sparsely populated and mainly used during the summer (Connah et al. 1977). This contrasts with evidence of larger populations on the nearby North Western Slopes.

Little is documented about how the Aborigines managed the land, as they were quickly displaced by the European invaders (Bowdler 1981). Explorers' notes of similar grassy woodland forest (for example, Mitchell 1848 referring to his crossing of the upper Hunter Valley in 1831) suggest that the understorey may have been burnt frequently for flushing game, stimulating growth of certain species and to ease access. This management regime may have reduced the number of saplings in the understorey, but there must have been sporadic regeneration events with appropriate climatic conditions. Aboriginal burning probably varied in different habitats. It was probably less frequent away from access routes and in the rougher granite and leucogranite regions of the study area. These areas contain shrubby species, many of which are in the same genera as the shrubs growing on Sydney sandstone that require variable fire regimes of between 8 and 25 years (Bradstock et al. 1995).

European exploration and settlement

A concise history of the early European explorations of the New England region is provided by Atchison (1977) and a history of the grazing industry is summarised in Nadolny (1998).

The first recorded European to traverse the Northern Tablelands was the Surveyor General John Oxley on his expedition of 1818 (Oxley 1820). The botanist Alan Cunningham accompanied Oxley.

The squatters moved in during the 1830s when Henry Dumaresq established the first pastoral run 'Saumarez' near modern-day Armidale. By 1839 pastoralists had moved north to Guyra (Atchison 1977). The large squatting runs withstood the threat of break up from the Robertson land acts in the 1860s. This legislation was designed to give free selectors the opportunity to take up and privatise land. An analysis of the impact of these acts on the New England pastoral runs revealed that the large pastoral runs mainly stayed intact (Ferry 1995).

It has been estimated that in the 1830s the Northern Tablelands were grazed by approximately 250 000 stock, with a stocking density of 0.6 sheep/ha (Campbell 1922 cited in Curtis 1989). By the late 1970s this increased to over 7 million, with 7 sheep/ha (Lodge et al. 1984) due to a combination of vegetation clearing and pasture improvement programmes (McDonald 1968 cited in Curtis 1989). Clearing would have been limited at first, but by 1890 about 10% of the Northern Tablelands had been ringbarked or cleared for grazing and cultivation. Curtis (1989) reports that teams of workers were employed on 'Saumarez' to ringbark and pull trees. Clearing was initially concentrated on the lower slopes and valleys where settlements were located. Lands close to mining areas were more intensively cleared. The two most active periods of clearing were 1870–1890 and after World War II. About 60% of the native tree cover has now been cleared across the Northern Tablelands (Benson 1999, Pressey et al. in press).

Pasture improvement, using a range of exotic grasses such as *Lolium perenne* and *Poa pratensis*, and legumes such as *Trifolium repens*, commenced in the 1920s but accelerated in the late 1940s. By 1973 19% of the region was sown to improved pasture. These imported grasses were aided in their establishment by the application of fertilizers, particularly superphosphate. Some of these pastures have been re-invaded by some native grasses and are termed natural pasture. Cultivation of crops has always been limited in extent.

Pre-European vegetation

At the time of European settlement the vast majority of the Northern Tablelands would have been covered in eucalypt forest and woodlands. Small patches of grassland would have occupied poorly-drained flats and river valleys that were affected by cold air drainage. Oxley (1820) observed and described a variety of forest vegetation. For example, he described travelling through 'the finest forest open country, or rather park, imaginable' (p. 291) as well as 'country … thickly timbered with stringybark and gum trees' (p. 293). However, Oxley's 'park-like' woodland should not be interpreted as an 'open woodland' as defined in Walker and Hopkins (1990). Tree density estimates indicate grassy woodlands of south-eastern Australia contained on average about 30 large trees/hectare (Benson & Redpath 1997).

Armidale was built on a small open plain north of the larger Salisbury plain — an area of treeless or lightly wooded grassland. In 1838 John Everett noted plenty of stringybark in the region, peppermint in the valleys and on the open plains, and a range of wildlife including the Bustard (Curtis 1989). The botanist Campbell (1922) mentioned stringybarks monopolizing the slate ridges with peppermints and gums in the valleys. While the tree species distribution is similar to that of today (Williams 1985), albeit reduced in extent, the understorey has changed significantly in disturbed areas.

Comparing today's forests with that depicted in early descriptions (summarised in Curtis 1989), it would appear that the structure of the vegetation on the more fertile soils has changed. The open forests with well spaced, large trees noted by Oxley in 1818 and others, are now rare. Much of the forest today is regrowth from early clearing, being densely grouped and small in stature (Davidson & Davidson 1992).

It is likely, however, that the forests on the poorer soils (such as on the leucogranite near Backwater) are little changed.

Whalley et al. (1978) postulate there were three main types of grassland understorey in the region prior to European settlement. *Poa sieberiana* and *Themeda australis* dominated more fertile soils at high elevation, the same two species along with *Sorghum leiocladum* dominated on podsolic and solodic soils at lower elevations, and *Themeda australis*, *Aristida ramosa* and *Cymbopogon refractus* dominated on soils on well-drained, coarse grained granites. The most palatable *Themeda* and *Sorghum* grasses have been grazed out in many areas, while the less palatable snow grasses (*Poa* spp.) have persisted.

Previous botanical studies

Early botanical papers on the general region of the Northern Tablelands included Christie (1877) who commented on the relationship between plant species and the main substrates, Turner (1903) who prepared a plant species list and Cambage (1904) who reported on vegetation to the west of the tablelands. Turner's list shows that many exotic species were established in the region by the turn of the century. A more complete list of vascular plants on the New England Tablelands was prepared by Gray (1961), while Beadle (1971–1987) produced a Flora covering the north-eastern section of NSW. Norton (1971) dealt with the grasses of the region. Williams (1963) described the types of vegetation from the eastern scarp to the western slopes. Most of the vegetation on the Guyra 1: 100 000 map sheet is described as 'disturbed remnant' in the broad classification of Roberts (1992). The relatively intact vegetation near Backwater is described as 'plateau sclerophyll complex' in Roberts (1992). This classification was derived from LANDSAT TM images and covers the north-eastern region of NSW. McIntyre et al. (1993) documents understorey species in grassy forest on the New England Tablelands and discusses aspects of their rarity and sparseness.

More specific botanical surveys of locations in the study area include: Clarke (1980) who mapped and surveyed the vegetation on the Newholme Field Centre at Mount Duval; Binns (1992) who analyzed the forest communities of the state forests in the Glen Innes region including Warra State Forest; Brock and Britton (1994) who studied seedbanks of wetland plants in the basalt lagoons near Guyra; Tremont (1995) who investigated the phenologies of a range of native forbs near Armidale; and Hunter and Clarke (1998) who documented the vegetation growing on the granitic outcrops of the New England Batholith. Additionally, the University of New England has conducted student studies in various parts of the study area.

The natural pastures of the region have been the subject of considerable study beginning with Roe (1947), who suggested that native pastures should not be neglected because they are an important source of summer feed, and were so widespread. Subsequently, Lodge and Whalley (1989) described the native pastures of the region and commented on their management in relation to grazing and the application of fertilizer. Nadolny (1998) discusses the history of pasture use in the region, including the use of sown exotic species.

Methods

The project consisted of two components. Firstly, plot based sampling of the vegetation was undertaken to assist with predicting species occurrences and with the development of a floristic classification. This sampling targeted the main environmental classes of the study area (Keith & Bedward 1999, Benson 1995, Neldner 1993). It used outputs from a geographical information system to guide the development of the sampling programme. Secondly, the vegetation was mapped from aerial photographs and ground traverses. The vegetation map units are primarily based on the numerically-derived floristic classification developed from the plot data.

Floristic sampling

The vegetation was sampled across the entire map sheet based on a stratification of variables considered to influence vegetation — parent material (substrate), altitude (as a surrogate for rainfall and temperature), aspect and topographic position in the landscape. Digital layers were obtained under licence from NSW National Parks & Wildlife Service of tree cover, geology and altitude classes to aid in this process using the geographical information system Environmental Resource Mapping System (ERMS) (Ferrier 1988). The tree cover was determined from LANDSAT TM interpretation (Roberts 1992). No attempt was made to survey derived native grasslands in places where the original tree cover had been cleared.

The complex array of geological units mapped on published and unpublished geology maps for the region had previously been simplified by geologists from the Department of Mineral Resources in cooperation with National Parks and Wildlife Service staff. For the Guyra area there were initially seven of these derived geological categories: basalt (33%), granite (25%), acid volcanics (7%), leucogranite (6%), sedimentary (high quartz) (< 1%), sedimentary (low quartz) (27%) and Quaternary sand and alluvium

(1%). For the purposes of stratifying sampling, the two sedimentary geological categories were combined along with the Quaternary Sand and Alluvium to derive a geology map with five categories of substrate. This geology map is displayed on the vegetation map.

The tree cover data of Roberts (1992) was superimposed on these five substrates (Fig. 4). Approximately 20% of the map sheet was recorded with woody vegetation (> 20% crown cover) at the time of the study, based on the LANDSAT mapping (Roberts 1992). However, this did not include remnants less than 50 ha, natural swamps, open woodland and native grassland areas. Tree cover was distributed unevenly across geologies as different parent materials and landforms give rise to soils and landscapes with differing agricultural capability.

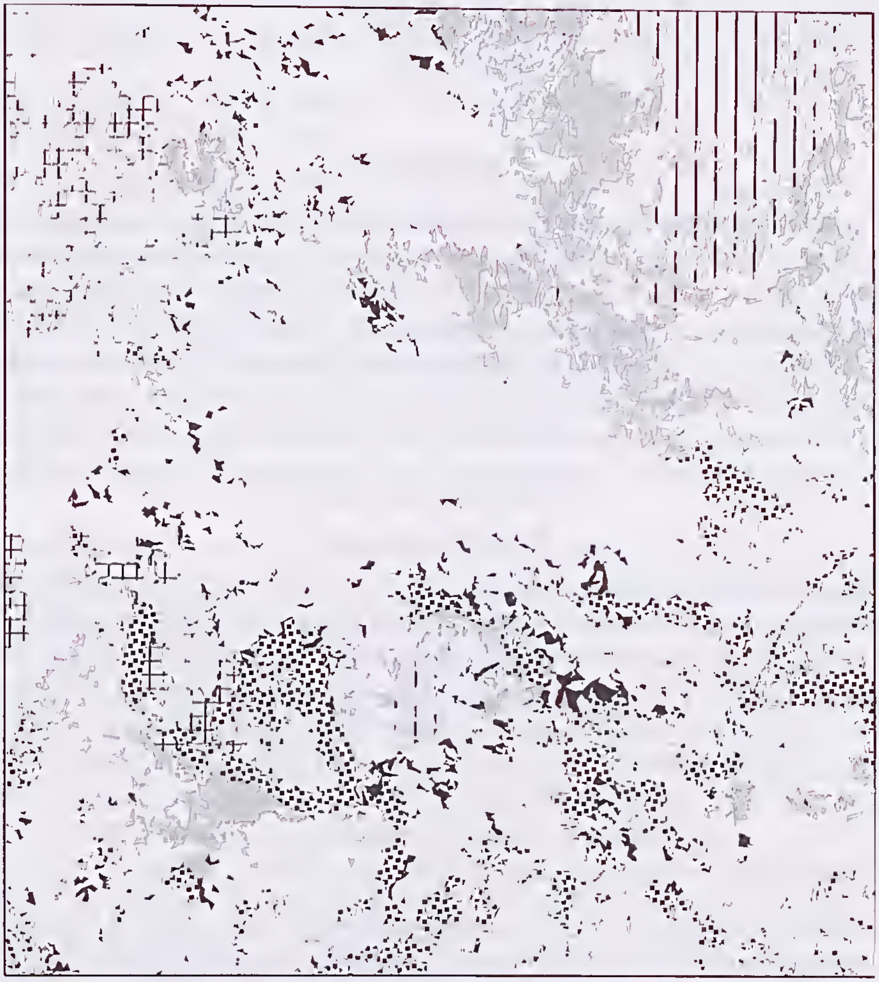

Fig. 4. Distribution of remnant vegetation detected from the LANDSAT TM image interpretation of Roberts (1992) over the five main substrates in the study area. Basalt = solid black, granite = light grey, leucogranite = vertical stripes, acid volcanic = checks, sedimentary = black blocks.

Using digitised terrain data in ERMS, altitude was classified into 6 bands: 900–1000 m, 1000–1100 m, 1100–1200 m, 1200–1300 m, 1300–1400 m, and > 1400 m. One category of slope was considered and aspect was considered to be of lesser importance to sample in parts of the study area with a gently undulating, basalt plateaux. Aspect was deemed to have a greater influence in the more dissected country at the mid-altitudes on non-basalt geologies.

The environmental cells and sampling requirements were developed by the following rules:

1. For landscape positions where aspect was irrelevant (ridge, flat and open depression) the number of sample sites was derived by multiplying five substrate types with six altitude classes by three replicates. This totalled 270.
2. For landscape positions requiring consideration of aspect (slopes greater than 5 degrees), the number of sample sites was derived by multiplying five substrate types with six altitude classes by four aspects by three replicates. This totalled 360.

The total number of sample sites required to sample all environmental cells defined in 1 and 2 above was 630 (sum of 1 and 2). However, it was found that considerably fewer sample plots were required in the field because some environmental cells were cleared (for example many sedimentary and alluvial areas), did not exist (for example, basalt at low altitudes), or existed very rarely and so could be discounted without great consequence (for example, low altitude granites).

Sampling intensity reflected the availability of vegetation on different geologies, with acid volcanics, basalt and leucogranites slightly over-sampled and granites and sedimentary and alluvium slightly under-represented (Table 1). Within the geology type, sample sites were spread across all available landscape positions (Table 2) and the sampling intensity tracked closely the relative availability of the various altitude classes (compare Table 2 with Table 1). Adequate replication and coverage of environmental cells was achieved by sampling a total of 312 sites. This included 12 sites in special habitats such as rocky outcrops and wetlands. Another consideration in the sampling stratification was geographic spread. In order to detect any geographic gradients, sample sites were spread across the map sheet where possible.

Sampling procedures

The vegetation was sampled in a total of 312 sites, each site being a 20 × 20 metre quadrat. This is a standard adopted by the National Herbarium of NSW as well as the NSW National Parks and Wildlife Service for coast and tablelands surveys (for example, Keith & Bedward 1999). The locations of these sites are shown on the vegetation map and details about them are stored on the flora survey database held by the Royal Botanic Gardens.

A total of 61 field days were spent by two person teams (i.e. 122 person days) to sample the vegetation. Twenty nine sites were sampled in December 1992, 36 in April 1993, 49 in October 1993, 117 in November 1993, and 80 in January 1994. Thus, in order to maximise the diversity of species recorded, sampling was spread across several seasons (spring, summer and autumn) and avoided the worst frost period May to

September (Fig. 3). However, at this time, the area was experiencing below average rainfall and the district was drought-declared for 11 of the 14 months of the study period (NSW Department of Agriculture pers. comm.). Plots were sampled once, so the plot data reflects the species present at one time.

All plant species were recorded in each quadrat and assigned a cover abundance based on a modified Braun-Blanquet 6-point scale (Poore 1955) (< 1%, 1–5%, 6–25%, 26–50%, 51–75%, 76–100%). The structure of the vegetation was also described by way of the number, type, height, crown cover and dominant species of each layer. A number of physiographic features were also noted for each site (slope, aspect, altitude, soil type, geology, azimuths) as well as an estimate of the degree and type of disturbance. Each site was located using a global positioning system device and verified and mapped on an aerial photo and 1: 25 000 topographic map for future reference.

Outside of the site sampling, the vegetation structure, dominant species and remnant size were also noted on topographic maps during extensive field traverses across the entire study area.

Plant species nomenclature conforms with that currently recognised by the National Herbarium of NSW and follows Harden (1990, 1991, 1992, 1993) and PlantNET (2000) for changes since Harden.

Table 1. Area (ha) of native vegetation remaining in each combination of geology and altitude compared with sampling intensity by geology (vegetation cover based on LANDSAT interpretation of Roberts 1992).

	Geology				
Altitude (m)	**Acid Volcanics**	**Basalt**	**Granites**	**Leucogranites**	**Sedimentary & Alluvium**
900–1000	0	0	69	166	416
1000–1100	10	648	1 091	2 334	5 687
1100–1200	2 475	1 067	3 218	4 121	5 912
1200–1300	2 400	1 690	4 414	3 621	5 054
1300–1400	317	1 777	8 066	455	274
1400 +	0	91	666	14	0
Total (ha)	**5 202**	**5 273**	**17 524**	**10 711**	**17 343**
	(9%)	(9%)	(31%)	(19%)	(31%)
No. of samples	**45**	**46**	**75**	**73**	**73**
	(14%)	(15%)	(24%)	(23%)	(23%)

Data analysis

All site data were entered into a relational database developed for vegetation data by NSW National Parks and Wildlife Service and used by the National Herbarium of NSW.

Data were investigated using multivariate techniques available in PATN (Belbin 1993) and unpublished software (Bedward pers. comm.). Floristic groups were determined by analysing presence/absence and cover abundance data. We selected the output generated by cover abundance data for the reasons outlined below.

Table 2: Number of sites sampled in each combination of environmental attributes. -= not sampled for reasons outlined in text.

Geology	Altitude (m)	Landscape position and aspect								
		Special Habitats	Ridge	Flat	Open Depression	North-facing Slope	East-facing Slope	South-facing Slope	West-facing Slope	Total
Acid Volcanics	900–1000	-	-	-	-	-	-	-	-	0
	1000–1100	-	-	-	-	-	-	-	-	0
	1100–1200	-	4	3	2	2	3	1	3	18
	1200–1300	-	5	2	-	4	4	3	2	20
	1300–1400	-	3	-	-	-	1	1	2	7
	1400 +	-	-	-	-	-	-	-	-	0
	Sub-total	**0**	**12**	**5**	**2**	**6**	**8**	**5**	**7**	**45**
Basalt	900–1000	-	-	-	-	-	-	-	-	0
	1000–1100	-	1	1	-	-	-	-	2	4
	1100–1200	-	3	1	-	1	1	1	1	8
	1200–1300	-	2	-	1	-	2	1	1	7
	1300–1400	7	2	4	-	2	2	3	-	20
	1400 +	-	4	-	-	1	1	1	-	7
	Sub-total	**7**	**12**	**6**	**1**	**4**	**6**	**6**	**4**	**46**
Granite	900–1000	-	-	-	-	-	-	-	-	0
	1000–1100	-	1	1	2	2	-	2	2	10
	1100–1200	-	3	4	2	1	3	3	3	19
	1200–1300	-	3	1	1	3	5	1	4	18
	1300–1400	2	5	1	-	2	4	3	4	21
	1400 +	-	2	-	-	2	1	1	1	7
	Sub-total	**2**	**14**	**7**	**5**	**10**	**13**	**10**	**14**	**75**
Leucogranite	900–1000	-	-	-	1	-	-	-	-	1
	1000–1100	-	3	4	3	2	2	3	3	20
	1100–1200	-	2	2	-	3	4	3	2	16
	1200–1300	3	3	4	2	3	3	3	3	24
	1300–1400	-	5	1	-	1	3	1	-	11
	1400 +	-	1	-	-	-	-	-	-	1
	Sub-total	**3**	**14**	**11**	**6**	**9**	**12**	**10**	**8**	**73**
Sedimentary & Alluvium										
	900–1000	-	-	2	-	-	-	1	1	4
	1000–1100	-	5	5	1	2	3	5	4	25
	1100–1200	-	4	2	1	3	6	3	4	23
	1200–1300	-	5	3	1	3	1	3	4	20
	1300–1400	-	1	-	-	-	-	-	-	1
	1400 +	-	-	-	-	-	-	-	-	0
	Sub-total	**0**	**15**	**12**	**3**	**8**	**10**	**12**	**13**	**73**
	Total	**12**	**67**	**41**	**17**	**37**	**49**	**43**	**46**	**312**

Presence/absence data are suitable to use where there are highly heterogeneous areas of vegetation to be classified (Lambert & Dale 1964, Orloci 1968), for example where there are variable ephemeral species such as in semi-arid herbfields and grasslands. For these reasons Benson et al. (1997) used presence/absence data in their analysis of the native grasslands of the Riverina. However, in less heterogeneous stands of vegetation, cover abundance data can assist classification (Goodall 1980). Cover abundance data provide a quantitative contribution of species dominance to a classification. This can deliver classifications that reflect ecological difference in places where perennial species comprise a high proportion of total species present. This would include most of eastern New South Wales. Faith et al. (1987) warn that abundance data can overly influence dissimilarities, although they also state that abundance data can minimise the impacts of sporadic or 'noisy' species which do not attain high abundances.

A hierarchical agglomerative classification was used to describe groupings of species and sites and their relationship to environmental features (Belbin 1991). The Kulczynski coefficient of dissimilarity was used. This coefficient is superior in ecological applications (Belbin 1993) because it describes the dissimilarity between sites based on their shared species composition and places no emphasis on the absence of species. This is particularly relevant in a fragmented landscape where species may be absent due to disturbance rather than due to an inherent likelihood of occurrence, or seasonal differences in time of sampling.

The homogeneity of the group associations was investigated using homogeneity analysis as presented in Bedward et al. (1992). A hierarchical classification of sites was then derived from a clustering strategy using a Beta value of -1 in a flexible unweighted pair group arithmetic averaging (UPGMA).

To check for misclassified sites in the resultant groups, a checking routine of nearest neighbours (Bedward, unpublished software) was used. This examines the nearest neighbours of all sites (as measured in the association matrix) and assesses whether any given site is grouped with its nearest neighbours. A misclassified site is one in a group where none of that site's nearest neighbours are present, and where none of the other sites in the group has that site as a nearest neighbour.

Once the classification was checked to conform with these criteria, the resulting dendrogram was investigated for environmental descriptors. The relationship between floristic composition and environmental variables was examined using a semi-strong hybrid multidimensional scaling ordination in two dimensions (SSH), as discussed in Belbin (1991, 1993) and Faith (1991).

Five environmental attributes were chosen for further investigaiton: altitude, geology, aspect, geographical position and topographical position. Although many other variables were recorded at each site (e.g. fire history, grazing pressure), these 5 were chosen as they were objectively measured and mappable. Categorical data of geology, slope and aspect were converted to continuous data. Geology was coded as an index for increasing nutrient status from 1 (poorest) to 5 (richest): leucogranite, acid volcanic, granite, sedimentary and basalt. Aspect and topographic position were coded as an index reflecting increasing exposure. A vector for each variable was fitted in the ordination using principal axis correlation (Belbin 1993). This produces a correlation coefficient measuring the fit of the vector with the association measures in ordination space. As few biological data conform to linearity along an environmental attribute gradient, the significance of a correlation coefficient is difficult to determine. In this case we used a Monte Carlo procedure for 1000 iterations, where correlation coefficent is recalculated for each randomisation. Thus, the significance of the original result is measured against the set of correlation coefficients possible from the data set.

Once the floristic groupings were finalised, a measure of fidelity to those groupings was generated for each species within that group (Bedward, unpublished software) to elucidate the contribution each species made to the definition of the group. The algorithm of Bedward follows the approach of Westhoff and van de Maarel (1980). It relates maximum proportion of occurrence of the species in any group to the sum of all proportions of occurrences in all groups. Species were selected as being indicators of each floristic group (plant community) when fidelity was set at a minimum of 0.8 and species occurred in at least 50% of sites within that group.

Vegetation mapping

Native vegetation was mapped at 1: 25 000 scale using the numerically-derived floristic groups as the basis for the map units. Aerial photo interpretation was undertaken only after the numerical analysis. This method contrasts with traditional vegetation mapping where patterns discerned by API have usually dictated the field sampling program and the definition of plant communities.

Colour aerial photographs at 1: 25 000 scale dated September 1989 (Land Information Centre 1989) were used to delineate native vegetation (excluding native grasslands) and to extrapolate vegetation patterns across the landscape. More recent aerial photography or satellite imagery were not analysed to ascertain recent clearing. Our observations suggest that only small areas were cleared during the 1990s, compared with the 1980s. A LANDSAT TM analysis of clearing in NSW from 1995–1997 detected less than 50 ha of clearing in the Guyra 1: 100 000 map sheet area (Environmental Research and Information Consortium 1998). If recent clearing was observed during field traverses, the map was modified. Recent ringbarking was mapped as cleared land, although in some places regrowth was occurring.

There was extensive field checking in February 1998 of the initial markup of vegetation units on the aerial photographs. All major and minor roads (including many farm tracks) were traversed.

Digital data for terrain, cultural features and drainage for all eight 1: 25 000 topographic map sheets that cover the Guyra 1: 100 000 map sheet were obtained from the Surveyor General's Department. 'Master positives' were produced from these data on archival matte film. A transfer scope was used to transfer the vegetation map unit boundaries from the aerial photographs to these master positives. The vegetation polygons were then digitised into ERMS and transferred into ArcView for analysis and presentation. Polygons were captured at 1: 25 000 scale and reduced to 1: 100 000 for the published map. Users of the 1: 100 000 map should be aware that the data exist at a larger scale and that hardcopies of 1: 25 000 maps can be issued on request.

Multi-attribute codes for typing the structure and floristics of the vegetation were applied. These were based on the structural classification of Walker and Hopkins (1990) and the codes used by the NSW NPWS (1995) in mapping the vegetation of upper north-eastern NSW. At sample sites we recorded actual measurements of height and density for each vegetation stratum. These site data assisted with applying attribute codes to each polygon delineated on the aerial photographs. These attribute codes are not shown on the printed map but can be generated from the GIS map coverage. The attributes assigned were:

- Height: 1 = > 25m; 2 = 12–25 m; 3 = < 12 m;
- Crown cover: a = < 10%; b = 10–30%; c = 30–50%; d = 50–80%; e = > 80%;
- Plant community number developed from the UPGMA classification, API or by field observation;
- API canopy disturbance categories:
  u = undisturbed
  d = estimated up to 25% thinned and/or lightly grazed;
  D = estimated 25–50% thinned/cleared and/or heavily grazed;
  s = scattered trees between 50% and 70% cleared and heavily grazed;
  A = > 70% cleared - agricultural land;
- API ground cover disturbance categories:
  y = natural ground cover (estimated to contain > 50% native plant cover);
  x = exotic ground cover.

An example of a composite code in a polygon is 2c17dy. This implies it is an open forest (2c), composed of plant community number 17 *Eucalyptus obliqua-Eucalyptus nobilis* (Messmate-Forest Ribbon Gum), which has been lightly disturbed (d), and has a native ground cover (y).

To assign an estimate of thinning, assumptions had to be made about the pre-European canopy. We assumed that the pre-European canopy of forests in the region were between one and two tree crown widths apart in valleys that contain medium to high nutrient soils (Benson & Redpath 1997, Curtis 1989) with denser (touching) crowns on steeper slopes and siliceous ridges. Canopy disturbance does not necessarily correspond to an equivalent degree of disturbance of lower strata.

The minimum sized remnant mapped is 1 ha. This is difficult to discern on the 1: 100 000 map sheet, but is quite visible at the 1: 25 000 scale .Small clumps of isolated trees in land that has been > 70% cleared are not delineated. Also, derived native grasslands (grasslands remaining after removal of woody canopy species) are not shown on the vegetation map.

The mapped plant communities closely reflect the floristic groups generated in the UPGMA. Some plant communities, such as New England Peppermint (*Eucalyptus nova-anglica*), swamps and wetlands were easily discernible from aerial photographs. Others, such as the four communities (2–5) composed of open forest dominated by various species of stringybark were difficult to separate. They were distinguished using site data and field traverse. As we could not field check every remnant, errors are likely to be present in the extrapolation of some communities across the landscape using API.

Riparian Shrubland (plant community 23), is restricted to narrow strips along watercourses and is not shown on the map. API was used to split *Eucalyptus stellulata* (Black Sallee Woodland, plant community 7) from *Eucalyptus viminalis-Eucalyptus dalrympleana-Eucalyptus pauciflora* (Ribbon Gum-Mountain Gum-Snow Gum Open Forest, plant community 6). API and ground traverse distinguished *Eucalyptus acaciiformis-Eucalyptus caliginosa-Eucalyptus radiata* subsp. *sejuncta* (Wattle-leaved Peppermint-Broad-leaved Stringybark-Narrow-leaved Peppermint Open Forest, plant community 19) from *Eucalyptus caliginosa* (Broad-leaved Stringybark Open Forest plant community 2) in the Avondale Road area north-east of Armidale. Using API and substrate, the poorly sampled and depleted *Eucalyptus nova-anglica* New England Peppermint occurring on basalt (plant community 8) was split from other New England Peppermint forests occurring on leucogranites/granites (plant community 10) and sediments/acid volcanics/western granites (plant community 9).

Exotic pine plantations and stands of poplar trees on farms were delineated on the aerial photographs but were not transferred to the vegetation maps.

The pre-European extent of the plant communities in the study area has not been accurately mapped or modelled. However, it has been estimated by examining the relationship of the extant distribution of plant communities with landscape position and substrate, and extrapolating this to cleared areas. This was done by comparing the 1: 25 000 topographic maps and the simplified geology map with the current distribution of the vegetation shown on the vegetation map. The pre-European extent of the plant communities was extrapolated over the geology, landforms and geographical locations most likely to have contained them. Aerial photographic interpretation along with field notes recorded during ground traverse assisted with these estimates. The pre-European extent of community 24 (basalt lagoons) was estimated by examining the topographic maps that depict most of the past (drained) and present lagoons.

Assessing the threat and reservation status of plant communities

Criteria for assessing the threat status of ecological or plant communities have been developed by Benson (1989), Hager and Benson (1994), Sattler and Williams (1999), English and Blyth (1999) and Environment Australia (2000). The remaining extent threshold criterion based on Benson (in review) and Environment Australia (2000) was used to assign a threat category to each plant community. This required comparing the GIS calculated measurement of the area of each plant community (excluding the unmapped riparian vegetation — community 23), with estimates of the proportion that had been cleared. These estimates were derived by examining clearing patterns in relation to landforms and existing remnants.

The threat codes used are:

CE = **'critically endangered'** implies that:

- it was a 'common' plant community at the time of European settlement (> 10 000 ha) and that > 90% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that > 80% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that > 70% of it has been cleared or severely degraded.

E = **'endangered'** implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that 70–90% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that 60–80% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that 50–70% of it has been cleared or severely degraded.

V = **'vulnerable'** implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that 50–70% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that 40–60% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that 30–50% of it has been cleared or severely degraded.

NT = **'near threatened'** implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that 35–50% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that 25–40% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that 15–30% of it has been cleared or severely degraded.

LC = **'least concern'** implies that:

- it was a'common'plant community at the time of European settlement (> 10 000 ha) and that < 35% of it has been cleared or severely degraded, or
- it was a 'naturally restricted' plant community (> 1000 < 10 000 ha original extent) and that up to 25% of it has been cleared or severely degraded, or
- it was a 'rare' plant community at the time of European settlement (< 1000 ha original extent) and that up to 15% of it has been cleared or severely degraded.

A reservation status code is assigned to each plant community for the study area. This is based on the proportion of the pre-European extent of each plant community that is represented in conservation reserves. The extant area of each plant community in reserves is calculated from the GIS, while the pre-European extent is an estimate. The reservation codes are based on the area reserved classes of Hager and Benson (1994):

- **VP** = 'Not or very poorly reserved' (i.e. < 1%);
- **P** = 'poorly reserved' (1–5%);
- **M** = 'moderately well conserved' (5–10%);
- **AC** = 'adequately conserved' (10–25%);
- **EC** = 'exceptionally well conserved' (> 25%).

State and national assessments of the threat and reservation status of the plant communities would be realised with further mapping of vegetation outside the study area, and modelling of its pre-European extent.

Results

Data Analysis

The dendrogram derived from the Kulczynski association and UPGMA clustering analysis (adjusted for misclassifications), is shown in Fig. 5. Twenty-one plant communities were defined at the dissimilarity measure of 0.7. Homogeneity analysis of these groups based on floristic composition reveals that 21 groups coincides with the first turning point of the homogeneity curve (Fig. 6). This is a desirable level of grouping because past this point there is less relative gain in homogeneity for further group definition i.e. the solution becomes less efficient (Bedward et al. 1992).

Major increases in homogeneity correspond with primary divisions in the dendrogram. At the first split of the dendrogram (and the first major increase in homogeneity), the forest and woodland groups pull away from the swamp, lagoon, river, scrub and rocky outcrop groups. The next significant point of division delineate the open forests of the leucogranite and granite geologies from the forest and woodlands of other geologies.

At a dissimilarity measure of approximately 1.0, 10 major groups are defined in the dendrogram and 70% of the homogeneity described by 21 groups has been reached.

These relationships were further investigated with ordination using Semi-Strong Hybrid- Multi-Dimensional Scaling in the PATN package (Fig. 7). Vectors fitted for easting (0.518), northing (0.691), nutrient rating (0.671) and altitude (0.484) were all significant at $p < 0.01$. Aspect (0.379) and topographic position (0.228) were significant at $p < 0.02$.

These numerical analyses revealed 21 floristic groups in 10 major groupings that were responding to a combination of environmental factors such as substrate, altitude and geographical position (the last two probably acting in concert as a surrogate for rainfall), together with availability of special habitat niches such as rocky outcrops and closed depressions (illustrated on Fig. 8). The floristic groups form the bulk of the vegetation units that are mapped. They are described in detail in a later section, but broadly, the 10 major groups delineated are:

1. Open forests on sedimentary substrates at mid-low altitudes with Blakely's Red Gum (*Eucalyptus blakelyi*) with Yellow Box (*Eucalyptus melliodora*) on lower slopes and Broad-leaved Stringybark (*Eucalyptus caliginosa*) on ridges (communities 1, 2, 19);
2. Open forests composed of Silver-topped Stringybark (*Eucalyptus laevopinea*) on various geologies at slightly higher altitudes than 1 above (communities 3 and 4);
3. Open forests composed of Youmans Stringybark (*Eucalyptus youmanii*) and *Eucalyptus subtilior* with Western New England Blackbutt (*Eucalyptus andrewsii*) on acid volcanic geology (community 5);
4. Tall open forests and open forests composed of Ribbon Gum (*Eucalyptus viminalis*), Snow Gum (*Eucalyptus pauciflora*), Black Sallee (*Eucalyptus stellulata*), Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) on basalt plateaux, and New England Peppermint (*Eucalyptus nova-anglica*) open forest and woodland in valleys on various substrates subjected to cold air drainage (communities 6–10);

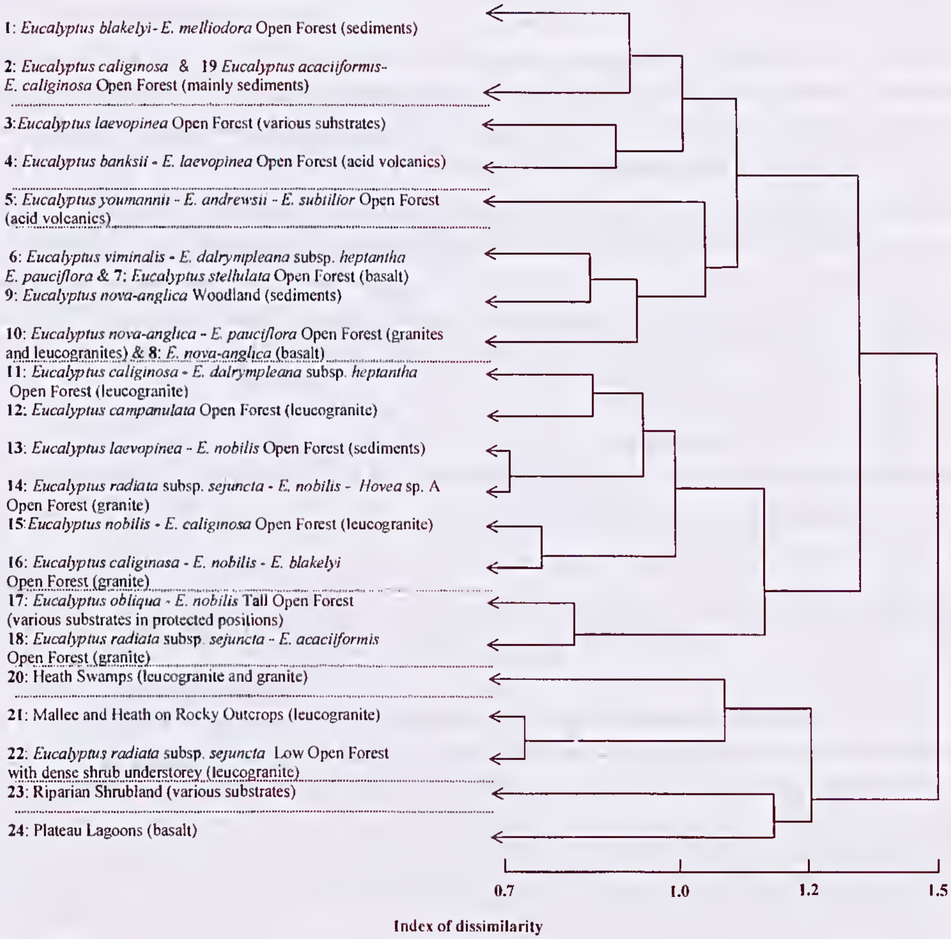
1: Eucalyptus blakelyi - E. melliodora Open Forest (sediments)
2: Eucalyptus caliginosa & 19 Eucalyptus acaciiformis- E. caliginosa Open Forest (mainly sediments)
3: Eucalyptus laevopinea Open Forest (various substrates)
4: Eucalyptus banksii - E. laevopinea Open Forest (acid volcanics)
5: Eucalyptus youmannii - E. andrewsii - E. subtilior Open Forest (acid volcanics)
6: Eucalyptus viminalis - E. dalrympleana subsp. heptantha E. pauciflora & 7: Eucalyptus stellulata Open Forest (basalt)
9: Eucalyptus nova-anglica Woodland (sediments)
10: Eucalyptus nova-anglica - E. pauciflora Open Forest (granites and leucogranites) & 8: E. nova-anglica (basalt)
11: Eucalyptus caliginosa - E. dalrympleana subsp. heptantha Open Forest (leucogranite)
12: Eucalyptus campanulata Open Forest (leucogranite)
13: Eucalyptus laevopinea - E. nobilis Open Forest (sediments)
14: Eucalyptus radiata subsp. sejuncta - E. nobilis - Hovea sp. A Open Forest (granite)
15: Eucalyptus nobilis - E. caliginosa Open Forest (leucogranite)
16: Eucalyptus caliginasa - E. nobilis - E. blakelyi Open Forest (granite)
17: Eucalyptus obliqua - E. nobilis Tall Open Forest (various substrates in protected positions)
18: Eucalyptus radiata subsp. sejuncta - E. acaciiformis Open Forest (granite)
20: Heath Swamps (leucogranite and granite)
21: Mallee and Heath on Rocky Outcrops (leucogranite)
22: Eucalyptus radiata subsp. sejuncta Low Open Forest with dense shrub understorey (leucogranite)
23: Riparian Shrubland (various substrates)
24: Plateau Lagoons (basalt)
0.7
1.0
1.2
1.5
Index of dissimilarity

Fig. 5. Dendrogram showing the plant communities in 10 major groupings (divided by dotted lines) produced using Kulczynski association and flexible UPGMA fusion strategy and a ß value of -0.1 (see text for detailed descriptions of the communities).

5. Open forest principally on leucogranites and granites and mainly in the north-east of the study area dominated by Broad-leaved Stringybark (*Eucalyptus caliginosa*), New England Blackbutt (*Eucalyptus campanulata*), Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) and Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) (communities 11–16);
6. Tall open forest composed of Messmate (*Eucalyptus obliqua*), Forest Ribbon Gum (*Eucalyptus nobilis*) and open forest composed of Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) and Wattle-leaved Peppermint (*Eucalyptus acaciiformis*), mainly on granites and leucogranites (communities 17–18);
7. Heath swamps on granites and leucogranites dominated by Sedges (Cyperaceae), Restionaceae and shrubs such as *Leptospermum gregarium*, *Banksia cunninghamii* subsp. A and *Epacris breviflora* (community 20);
8. Mallee Ash (*Eucalyptus codonocarpa*) with a dense heath-shrub understorey leucogranite on rocky outcrops, and Low Open Forest containing Broad-leaved Stringybark (*Eucalyptus caliginosa*) and Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) with a tall dense shrub understorey composed of shrubs such as *Mirbelia confertiflora*, *Petrophile canescens* and *Leptospermum novae-angliae* on coarse sands on leucogranite (communities 21–22);

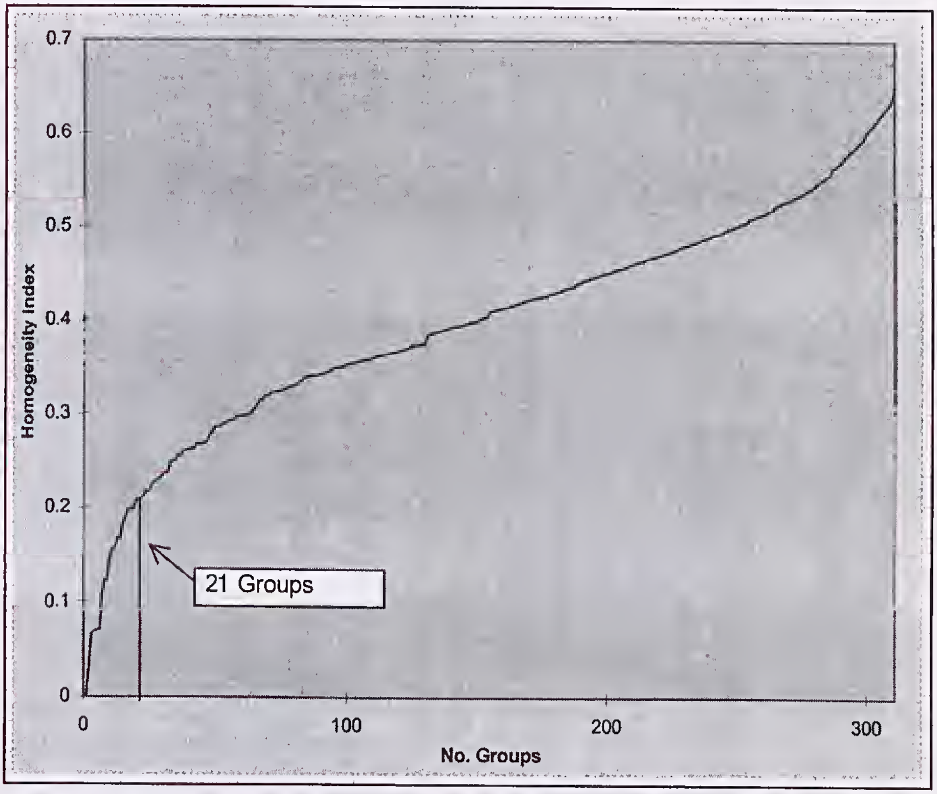

Fig. 6. Homogeneity of full floristic composition with increasing number of groups.

9. Riparian shrubland dominated by *Leptospermum polygalifolium* subsp. *transmontanum* on a number of substrates (community 23);
10. Water plants of the genera *Potamogeton*, *Myriophyllum*, *Eleocharis*, *Juncus*, and *Nymphoides* growing in open water in shallow lagoons on basalt (community 24).

Floristic composition

A total of 889 plant taxa in 118 families (18 families of pteridophytes, one family of gymnosperm and 99 families of angiosperms) have been recorded for the study area (Appendix 1). This represents 14% of the NSW flora. Only vascular plants were included in the survey.

A total of 681 taxa were recorded during the survey, the remaining 208 taxa were cited from herbaria collections and records supplied by local botanists. Of the total number of taxa, 743 were native and 146 (17%) were exotic being mainly pasture weeds. Families of angiosperms that contained 10 or more taxa are: Apiaceae (20); Asteraceae (97); Brassicaceae (10); Cyperaceae (43); Epacridaceae (18); Fabaceae (77); Juncaceae (20); Lamiaceae (10); Myrtaceae (41) (including 27 *Eucalyptus* species); Orchidaceae (44); Poaceae (135) (including 13 *Austrodanthonia*, 6 *Poa*, 8 *Eragrostis*, 7 *Aristida*, 10 *Austrostipa*, 7 *Deyeuxia*); Polygonaceae (12); Proteaceae (15); Rhamnaceae (10); Rubiaceae (14); Rutaceae (12); and Scrophulariaceae (19).

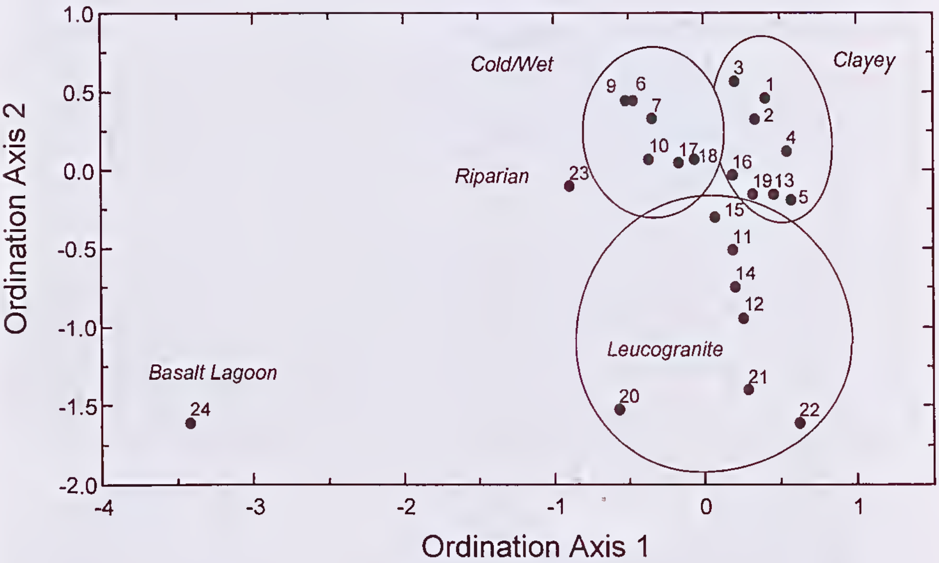

Fig. 7. Distribution of sites (centroids, labelled by plant community) in two-dimensional space. Five groups are evident in the ordination. Basalt Lagoon (24) and New England Riparian Shrubland (23) are highly distinct; communities 11, 12, 14, 15, 20, 21 & 22 occur on leucogranite; communities 1–5, 16 and 19 occur on clay soils derived from either sedimentary or acid volcanic substrate; and communities 6, 7, 9, 10, 17 & 18 experience cold temperature and/or high soil moisture at high altitudes or in valley bottoms.

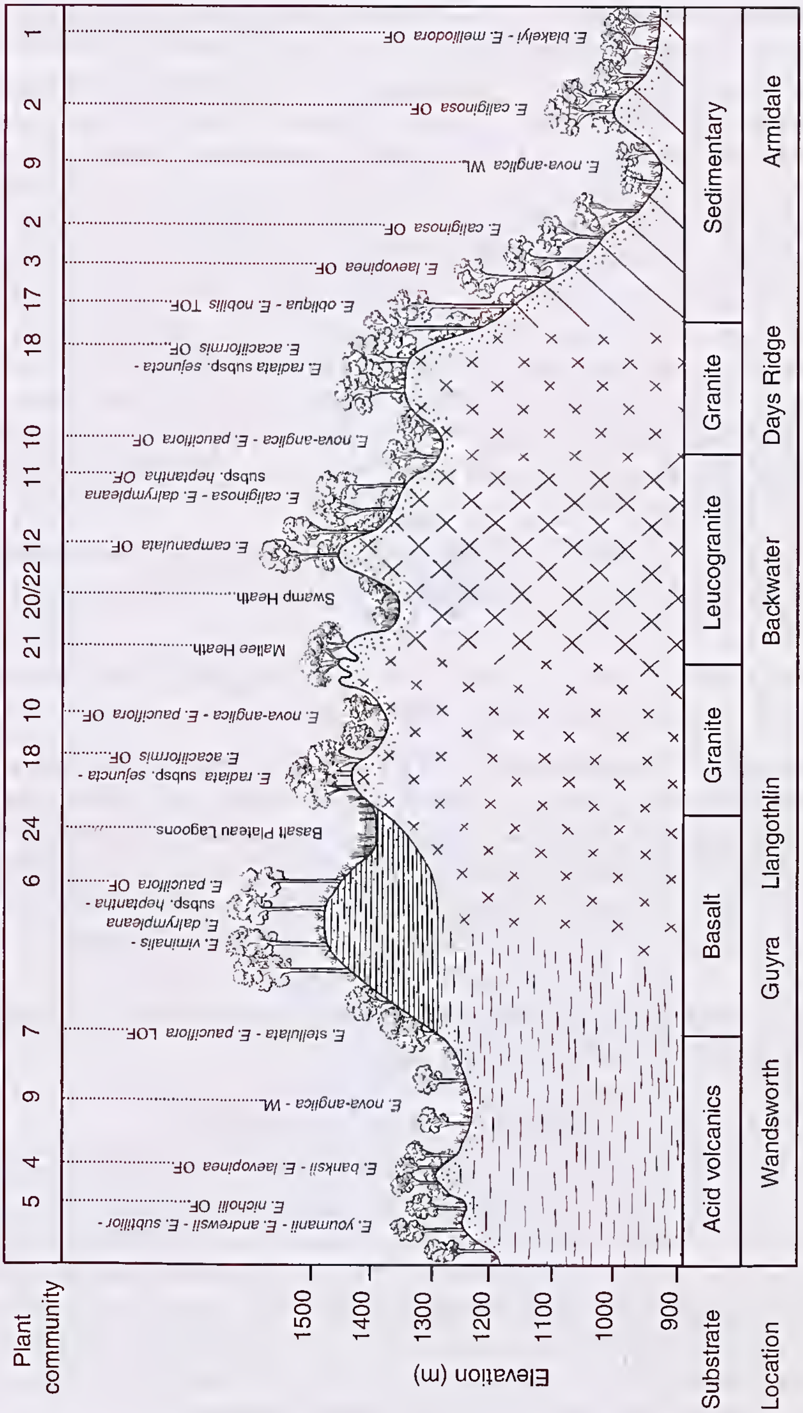
Plant community
5
4
9
7
6
24
18
10
21
20/22
12
11
10
18
17
3
2
9
2
1
E. youmanii - E. andrewsii - E. subtilior - E. nicholii OF
E. banksii - E. laevopinea OF
E. nova-anglica - WL
E. stellulata - E. pauciflora LOF
E. viminalis - E. dalrympleana subsp. heptantha - E. pauciflora OF
Basalt Plateau Lagoons
E. radiata subsp. sejuncta - E. acaciiformis OF
E. nova-anglica - E. pauciflora OF
Mallee Heath
Swamp Heath
E. campanulata OF
E. caliginosa - E. dalrympleana subsp. heptantha OF
E. nova-anglica - E. pauciflora OF
E. radiata subsp. sejuncta - E. acaciiformis OF
E. obliqua - E. nobilis TOF
E. laevopinea OF
E. caliginosa OF
E. nova-anglica WL
E. caliginosa OF
E. blakelyi - E. melliodora OF
Elevation (m)
1500
1400
1300
1200
1100
1000
900
Substrate
Acid volcanics
Basalt
Granite
Leucogranite
Granite
Sedimentary
Location
Wandsworth
Guyra
Llangothlin
Backwater
Days Ridge
Armidale

Fig. 8. Schematic transect of the landscapes present in the area covered by the Guyra 1: 100 000 map sheet showing the relationship between topographic position, elevation, substrate and plant communities. OF = Open-Forest, WL = Woodland, LOF = Low Open-Forest, TOF = Tall Open-Forest (after Walker & Hopkins 1990).

By examining Appendix 1 it can be seen that widespread (present in 75% of the communities) and commonly recorded taxa were: *Pteridium esculentum, Cheilanthes sieberi* subsp. *sieberi, Dichopogon fimbriatus, Hydrocotyle laxiflora, Brachyscome microcarpa, Senecio* sp. E, *Wahlenbergia stricta* subsp. *stricta, Scleranthus biflorus, Hypericum gramineum, Dichondra repens, Crassula sieberiana, Hibbertia linearis, Leucopogon lanceolatus* var. *lanceolatus, Melichrus urceolatus, Poranthera microphylla, Acacia dealbata, Acacia filicifolia, Desmodium varians, Hardenbergia violacea, Geranium solanderi* subsp. *solanderi, Gonocarpus tetragynus, Luzula densiflora, Ajuga australis, Lomandra longifolia, Lomandra multiflora* subsp. *multiflora, Eucalyptus caliginosa, Eucalyptus dalrympleana* subsp. *heptantha, Eucalyptus nobilis, Eucalyptus radiata* subsp. *sejuncta, Leptospermum polygalifolium* subsp. *transmontanum, Oxalis radicosa, Bursaria spinosa, Plantago gaudichaudii, Cymbopogon refractus, Austrodanthonia racemosa, Dichelachne micrantha, Echinopogon* spp., *Elymus scaber, Poa sieberiana, Austrostipa rudis* subsp. *nervosa, Themeda australis, Lomatia silaifolia, Ranunculus lappaceus, Acaena novae-zelandiae, Rubus parvifolius, Asperula conferta, Galium ciliare, Opercularia* spp., *Veronica calycina, Veronica plebeia* and *Viola betonicifolia.*

The most common weeds recorded were: *Hypochaeris radicata, Cirsium vulgare, Conyza albida, Taraxacum officinale, Trifolium repens, Anthoxanthum odoratum, Aira elegantissima* and *Rubus ulmifolius.*

Most species are sparsely distributed in the landscape and relatively few occur frequently across a number of plant communities.

Certain groups of plants tended to be more frequently recorded in some plant communities. For example, community 17, *Eucalyptus obliqua-Eucalyptus nobilis* contained more ferns than other communities. Communities 23 (riparian shrubland) and 24 (lagoons) contained more sedges (Cyperaceae) than other communities. More grasses were recorded in communities on higher nutrient soils, for example communities 1, 6, 7 and 9 than on low nutrient soils such as communities 11, 12, 20–22 which are restricted to leucogranite. This trend was reversed for species in the Proteaceae where more species from this family were recorded on the low nutrient soils compared to high nutrient soils.

Rare or threatened plant species

A total of 28 rare or threatened taxa has been recorded from the study area (Table 3) of which 10 were recorded in our survey. The remaining 18 species are from collections in the N.C.W. Beadle Herbarium of the University of New England, the National Herbarium of NSW, and various survey records. 25 of these taxa are listed in the national listing of rare or threatened Australian plant species (ROTAP) (Briggs and Leigh 1995). Nine of these taxa along with two other species, *Monotaxis macrophylla* and *Aldrovandra vesiculosa* (which are more common in other states but endangered in NSW), are listed in Schedules 1 or 2 of the NSW Threatened Species Conservation Act 1996. One unlisted species recorded in the survey, *Brachyloma saxicola*, could be considered nationally rare (Briggs and Leigh 1995) or Near Threatened using the criteria of IUCN (1999).

Table 3. List of rare or threatened plant species recorded from the Guyra 1: 100 000 map sheet area.

ROTAP code refers to Briggs and Leigh (1995). TSC Act refers to the threat category under the *NSW Threatened Species Conservation Act 1996*.

Species name	ROTAP Code	NSW TSC Act
Acacia brunioides subsp. *brunioides*	3RC-	Not listed
Aldrovandra vesiculosa	Not listed	Endangered
Asperula charophyton	3RCa	Not listed
Bothriochloa biloba	3V	Vulnerable
Brachyloma saxicola	Not listed (suggest 3RCa)	Not listed
Brasenia schreberi	3RC-	Not listed
Callitris oblonga subsp. *parva*	3VCa	Vulnerable
Cryptandra lanosiflora	3RCa	Not listed
Daviesia elliptica	3RC-	Not listed
Dichanthium setosum	3VC-	Vulnerable
Discaria pubescens	3RCa	Not listed
Eucalyptus camphora subsp. *relicta*	3VC-	Endangered
Eucalyptus codonocarpa	3RC-	Not listed
Eucalyptus michaeliana	3RCa	Not listed
Eucalyptus nicholii	3V (suggest 3VC-)	Vulnerable
Eucalyptus youmanii	2R (suggest remove)	Not listed
Euphrasia orthocheila	3RC-	Not listed
Goodenia macbarronii	3VC-	Vulnerable
Grevillea scortechinii subsp. *sarmentosa*	3VC-	Vulnerable
Monotaxis macrophylla	Not listed	Endangered
Muehlenbeckia costata	3KC-	Not listed
Persoonia procumbens	2RC-	Not listed
Leionema ambiens	3RC-	Not listed
Pseudanthus divaricatissimus	3RCa	Not listed
Pultenaea campbellii	3V (suggest R or remove)	Not listed
Thelionema grande	3RC-	Not listed
Thesium australe	3VCi (suggest R)	Vulnerable

Discussions of the rare or threatened taxa follow. Risk codes in capital letters are from Briggs and Leigh (1995) — consult this for an explanation of the codes. Codes in lower case refer to the taxon's listing under the NSW Threatened Species Conservation Act.

Acacia brunioides subsp. ***brunioides*** (Fabaceae) (3RC-): This shrub was recorded once in community 12 along the Sara River. This rare species is restricted to granite substrates in the New England Bioregion of NSW and Queensland.

Aldrovandra vesiculosa (Droseraceae) (e): This free floating aquatic herb was not recorded during the survey but has since been recorded in Llangothlin and Billy Bung Lagoons near Guyra (D. Bell pers. comm.). This species seems to appear and disappear in wetlands and has a low seed set. It is probably introduced by migratory waterbirds from time to time. It is a cosmopolitan species but it is likely the Australian entity is taxonomically distinct from the European one (S. Jacobs pers. comm.).

Asperula charophyton (Rubiaceae) (3RCa): This forb was recorded once during the survey on the edge of Mother of Ducks Lagoon in community 24 (basalt lagoon), near the town of Guyra. It would appear to be very restricted in the study area but is recorded from the Warrumbungles National Park in the Nandewar Bioregion (north-western slopes).

Bothriochloa biloba (Poaceae) (3V) (v): This grass was once widespread and there are collections in the National Herbarium of NSW from western Sydney, the Hunter Valley, the Northern Tablelands and most commonly on the North Western Slopes near Inverell and Warialda. It has probably been reduced by grazing and cultivation and is not known to be conserved in a reserve. Recent surveys of the western slopes and plains indicate that the species may still be common in some places (Department of Land and Water Conservation pers. comm.). If so, the species may warrant removal from Schedule 2 of the TSC Act and down listing on ROTAP. While not recorded during the survey, there is a National Herbarium of NSW record collected from the New England Highway between Guyra and Armidale in 1955 by M. Gray.

Brachyloma saxicola (Epacridaceae): This shrub is restricted to seven areas of granitic outcrops on the Northern Tablelands (Hunter & Williams 1994). It was recorded a number of times in our survey on granitic rocky outcrops in the Backwater area (community 21). Hunter and Williams (1994) suggested this species should be coded 2VC under Briggs and Leigh (1995). This was revised by Richards and Hunter (1997) who suggested a ROTAP code of 3RCa. We consider it is not threatened and therefore should be coded as 3RCa under ROTAP and as Near Threatened under IUCN (1999).

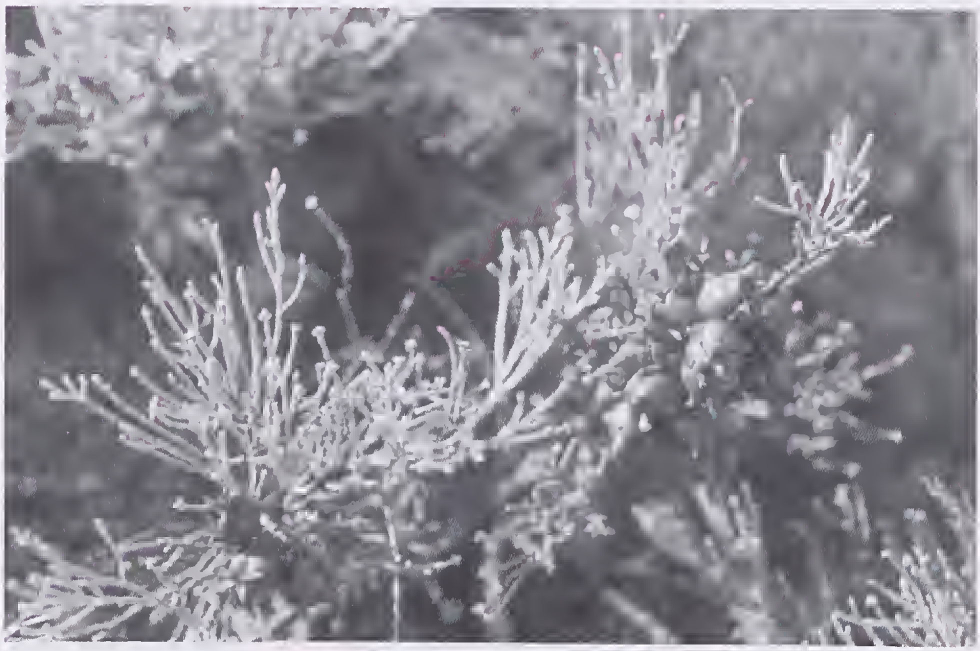

Fig. 9. The threatened native conifer *Callitris oblonga* subsp. *parva* grows along several creeks in the study area and is susceptible to frequent fire.

Brasenia schreberi (Cabombaceae) (3RC-): This stoloniferous aquatic herb was not recorded during the survey, but has recently been collected from Llangothlin Lagoon (D. Bell pers. comm.). It occurs spasmodically in wetlands in eastern Australia and other parts of the world.

Callitris oblonga subsp. ***parva*** (Cupressaceae) (3VCa) (v): There are three subspecies of this taxon which is commonly known as Pigmy Cypress Pine: subsp. *oblonga* occurs in northern Tasmania, subsp. *corangensis* grows along the Corang River on the Southern Tablelands of NSW, and subsp. *parva* occurs in a number of locations on the Northern Tablelands of NSW. The distribution of the NSW locations of *Callitris oblonga* is documented in Nadolny and Benson (1993). In the study area, *Callitris oblonga* subsp. *parva* (Fig. 9) is restricted to leucogranite in the Backwater area, particularly along the Sara River, Stuttering Dicks Creek and Backwater Creek. It is mainly restricted to community 23 (riparian shrubland). The species is threatened by too-frequent fire and other disturbances along the watercourses where it grows.

Cryptandra lanosiflora (Rhamnaceae) (3RCa): This rare stunted shrub occurs on the Northern Tablelands and the tablelands of southern Queensland. J.T. Hunter collected this species in 1996 from leucogranite outcrops north of Backwater.

Daviesia elliptica (Fabaceae) (3RC-): This shrub was recorded once during the survey in community 10 adjacent to the Sara River near Mount Mitchell on leucogranite. This is the southern-most record for the species. It is very rare in the study area but National Herbarium of NSW collections reveal it is present on granite to the north in Boonoo Boonoo National Park, near the Timbarra River on the Glen Innes-Grafton Road and on the Darling Downs in Queensland. This species requires a targeted survey to establish its abundance and threat status.

Dichanthium setosum (Poaceae) (3VC-) (v): This grass is known from the Northern Tablelands, Western Slopes, North Western Plains and Queensland. National Herbarium of NSW records from the 1940s reveal that it grew along the Guyra-Ebor Road. The UNE herbarium has a record of this species from the original 'Saumarez' landholding, just south of Armidale. This grass would appear to be rare and requires specific surveys to establish its status.

Discaria pubescens (Rhamnaceae) (3RCa): This widespread rare shrub occurs along the tablelands of NSW in areas that have been protected from intense grazing. It was not recorded during the survey, but herbarium records reveal it has been collected from the Paddys Gully area near Backwater, Oban River, near Boorolong and near Guyra during the period 1967–1989. It was also recorded in Little Llangothlin Nature Reserve in 1994 (D. Bell pers. comm.).

Diuris pedunculata (Orchidaceae) (2E) (e): This ground orchid is probably the most endangered plant species in the study area and one of the rarest on the Northern Tablelands in general. It was not recorded during the survey but there is a herbarium record from 'Hardacres' near Boorolong (UNE herbarium database) and several records from the 1930s and 1940s by McKie for 'just south of Guyra'. Over the last decade the species has been found on the railway easement near Armidale (but could not be re-located there in 1994, Metcalfe pers. comm.), adjacent to the New England

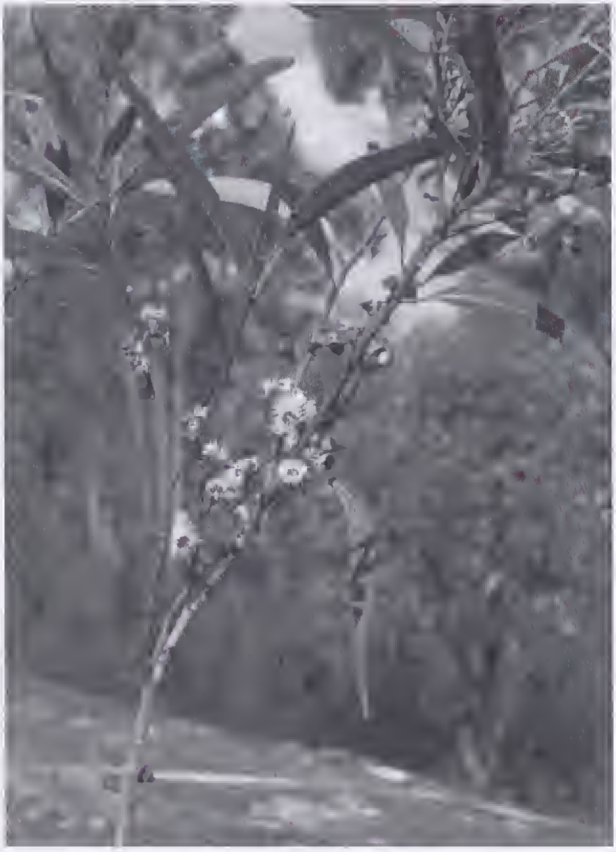

Fig. 10. The mallee, *Eucalyptus codonocarpa*, is listed as a rare species nationally. It occurs on rocky leucogranite outcrops near Backwater.

highway south of Uralla, near the Ebor Trout Hatchery and near 'Sandy Creek' on a travelling stock reserve (TSR) on the Guyra-Inverell Road north-west of Guyra. It would appear this is a critically endangered species requiring special research and conservation effort.

Eucalyptus camphora subsp. ***relicta*** (Myrtaceae) (3VC-) (e): A small population of this species occurs in the northern edge of the Guyra map sheet overlapping onto the Glen Innes map sheet to the north. Its only population in the study area is in a heath-swamp (community 20) along a creek on the eastern side of Crown Mountain in Warra National Park (formerly state forest). There are only a few other localities for this taxon and it is correctly ranked as an endangered subspecies in NSW.

Eucalyptus codonocarpa (Myrtaceae) (3RC-): This mallee-eucalypt is restricted to granite outcrops on the Northern Tablelands and is found in Gibraltar Range, Cathedral Rock and Girraween National Parks. In the study area it was confined to community 21 on leucogranite outcrops north of Backwater (Fig. 10). If some of the leucogranite country at Backwater was protected in reserves, this species should then be considered adequately reserved ie 3RCa.

Eucalyptus michaeliana (Myrtaceae) (3RCa): This species is most common on the escarpment of the Macleay gorges to the south-east of the study area (NSW NPWS 1985). There is a single University of New England record of this species in the study area, at Brookside along the Rockvale Road. Despite searching for it in this area the species was not recorded during the survey.

Eucalyptus nicholii (Myrtaceae) (3V) (v): This species was recorded only in community 5. It occurs mainly on acid volcanic substrates in the north-western section of the study area and is more common further west near Tingha. Most of its habitat has been cleared and little is protected in reserves, although the proposed Moredun Creek Nature Reserve to the west of the map sheet, if declared, would protect a stand of this species. The recent dedication of Single State Forest as a national park protects a stand of *Eucalyptus nicholii* west of the study area.

Eucalyptus youmanii (Myrtaceae) (2R): This stringybark was recorded in community 1 and in community 5. Most of its habitat has been cleared and it is poorly represented in reserves. It is not as rare as previously thought and should be removed from ROTAP. However, it is not as widespread as other stringybark species on the Northern Tablelands.

Euphrasia orthocheila (Scrophulariaceae) (3RC-): There is one specimen in the National Herbarium of NSW from the study area 12 km east of Guyra collected by J. Boorman in 1917. It was not recorded during the survey. It has been recorded in Girraween and Mount Kaputar National Parks.

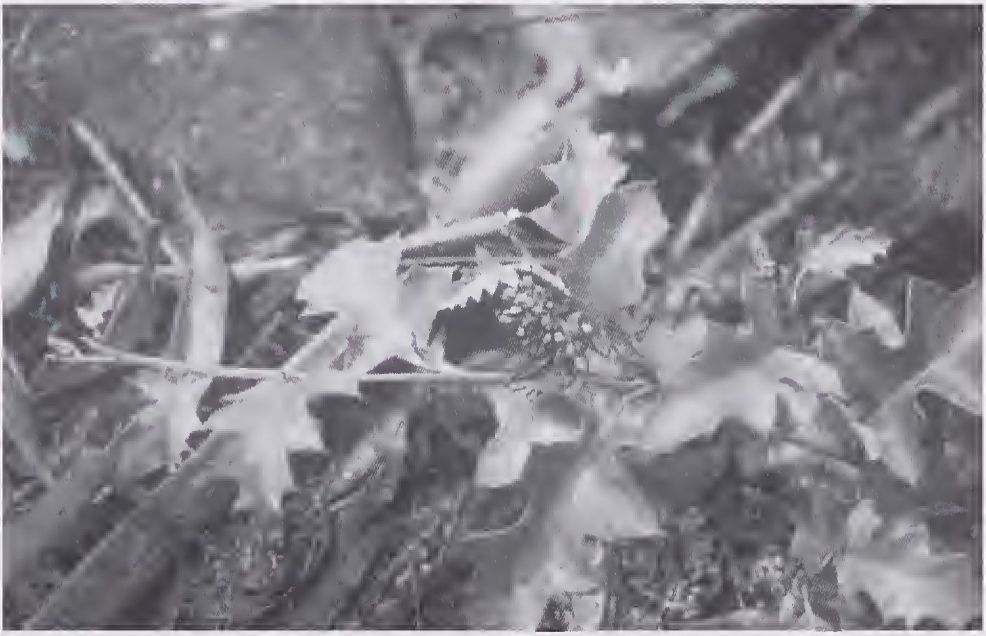

Fig. 11. *Grevillea scortechinii* subsp. *sarmentosa* is listed as vulnerable species nationally. It is restricted to the leucogranite outcrops northeast of Backwater in the study area.

Goodenia macbarronii (Goodeniaceae) (3VC-) (v): This forb was not recorded during the survey, but two old specimens from the area are held in the National Herbarium of NSW. One from Chandlers Peak near Guyra was collected by Boorman in 1917, and another from Moredun Creek, collected by E. McKie in 1948. Most collections of this species are from the Pilliga Scrub region on the North Western Slopes. This species may be extinct on the Northern Tablelands.

Grevillea scortechinii subsp. ***sarmentosa*** (Proteaceae) (3VC-) (v) (Fig. 11): This decumbent shrub is restricted to a few granite outcrops on the Northern Tablelands. It was recorded in communities 11, 12, 19, 22, and 23. It was found to be locally common in forests on the leucogranite outcrop north of Backwater. If some of its populations were protected for conservation in this area this species should be down-listed to the rare category in ROTAP and/or Near Threatened in IUCN (1999). It should be removed from Schedule 2 (vulnerable) of the TSC Act.

Monotaxis macrophylla (Euphorbiaceae) (e): Collected once in the area by J.T. Hunter. This is a new record for the Northern Tablelands where it was located growing in post-fire regrowth on leucogranite near Backwater. In the National Herbarium, there are specimens collected in 1904 from the North-western Slopes and North-western Plains and in 1991 from the South Coast. This species appears to be very rare and may require certain fire regimes to persist.

Muehlenbeckia costata (Polygonaceae) (3KC-): This decumbent scrambler occurs on and between rocky outcrops in Warra National Park (J.T. Hunter pers. comm.). This species is a fire ephemeral and germinates prolifically after fire but then dies back soon afterwards (Hunter et al. 1998). It has also been recorded in Bald Rock and Girraween National Parks to the north and Butterleaf State Forest to the east of the study area. Given its rarity and dependence on certain fire regimes, it should be listed as a vulnerable species under both ROTAP and the TSC Act.

Persoonia procumbens (Proteaceae) (2RC-): This low growing shrub has a similar distribution to *Grevillea scortechinii* subsp. *sarmentosa* in that it grows on granite substrates on the Northern Tablelands. It was recorded in communities 11, 12 and 14. It occurs in Warra National Park, but its largest populations in the study area are on private land near Backwater.

Leionema ambiens (Rutaceae) (3RC-): This shrub is restricted to some of the rocky outcrops in the Warra National Park and also occurs near Backwater in community 21. It has been collected in the northern part of the Northern Tablelands at Bald Rock, Timbarra, Tenterfield and Bismuth and occurs in Queensland.

Pseudanthus divaricatissimus (Euphorbiaceae) (3RCa): This prostrate shrub occurs in small populations from East Gippsland along the Great Dividing Range to Queensland. It has been collected by J.T. Hunter from the leucogranite in the study area.

Pultenaea campbellii (Fabaceae) (3V): This shrub is mainly located on acid volcanic substrates in the north-western section of the study area. It has been recorded in communities 1, 2 and 5. This species is not vulnerable and could be removed from ROTAP. It has recently been removed from schedule 2 of the NSW TSC Act.

Thelionema grande (Phormiaceae) (3RC-): This tufted herb has been found on sandy soils derived from granites. It occurs on the New England Tablelands in southern Queensland and NSW. In NSW this species has been collected at Boonoo Boonoo, Tenterfield and Torrington. J.T. Hunter collected it in the mid-1990s on leucogranite near Backwater.

Thesium australe (Santalaceae) (3VCi) (v): A widespread semi-parasitic forb occurring from Victoria to Queensland. It has probably been reduced in abundance due to grazing (Archer 1984). In NSW it is conserved in a number of north coast reserves and Kosciuszko National Park, and Namadgi National Park in the ACT. It was recorded in community 6 on basalt and in community 18 on granite. Most of these sites are in strips of roadside vegetation. It is usually found with the grass *Themeda australis* which it parasitises (Griffith 1992). Other populations in the study area have recently been documented by the University of New England including several in Little Llangothlin Nature Reserve (D. Bell pers. comm.). It would appear that this rather cryptic forb may be more common than previously thought and could be considered rare rather than vulnerable. Its conservation would be enhanced if protection could be afforded to some of its known populations near Guyra.

Regionally rare species

Using the results of the survey and herbaria data, it would appear that a number of plant species could be considered rare in the context of the study area, although many of these are known to be more common elsewhere. The following list includes some of the species that were recorded once during the survey, and/or species that have been rarely collected in the past, but known from herbaria collections from the area. Plants were excluded from the list if they are known to respond to seasonal conditions or occur in habitats that have not been thoroughly surveyed. These include most of the grasses, geophytes such as orchids, various families of water plants, and most of the sedges (Cyperaceae) and rushes (Juncaceae).

After applying this filter, species deemed to be regionally rare in the area covered by the Guyra 1: 100 000 map sheet are:

- the ferns *Blechnum minus* and *Botrychium australe;*
- the forbs *Eryngium ovinum, Hydrocotyle peduncularis, Caesia parviflora, Burmannia disticha, Centrolepis strigosa, Atriplex semibaccata, Chenopodium carinatum, Swainsona monticola, Swainsona oroboides, Centaurium spicatum, Geranium retrorsum, Goodenia gracilis, Velleia paradoxa* and *Plantago varia;*
- the sedges *Baumea nuda* and *Caustis pentandra;*
- the daisies *Lagenifera gracilis, Microseris lanceolata, Olearia alpicola, Olearia cydoniifolia, Olearia rosmarinifolia, Podolepis jaceoides, Podolepis neglecta, Pseudognaphalium luteoalbum, Senecio bipinnatisectus, Senecio gunnii, Stuartina muelleri, Vittadinia dissecta* var. *hirta;*
- the shrubs *Acacia leucolobia* (extension of range), *Daviesia acicularis, Bossiaea prostrata, Dillwynia juniperina, Pultenaea myrtoides, Sphaerolobium minus, Prostanthera nivea, Persoonia oleoides, Pomaderris andromedifolia, Pomaderris eriocephala, Boronia microphylla, Santalum obtusifolium, Zieria laevigata, Tasmannia stipitata;*

- the grass, *Poa clivicola* was recorded once at site 235 in New England Peppermint regrowth, a northern extension of its range. A northern form of *Poa costiniana* was recorded at a number of sites, mainly in community 6 on basalt.

Description of plant communities

Approximately 69 000 ha or 26% of the Guyra 1: 100 000 map sheet area was mapped as native vegetation using aerial photographic interpretation. However, as mentioned previously, we did not map native grasslands or patches of vegetation less than one hectare in size.

The 24 mapped plant communities are described below, complemented by a photograph of each community. Some are more homogeneous in their floristic composition than others. Some are widely distributed, for example communities 2, 3, 17 and 23. Others are geographically restricted, for example communities 13, 14, 20, 21 and 24. The fidelity analysis (Bedward unpublished software) revealed that the ubiquitous stringybark plant communities 2 and 3 contain one and no indicator species respectively. Most species in them are common across the landscape. In contrast, communities 24 (swamps on basalt) and 21 (rocky outcrops on leucogranite) contain a large number of indicator species that are restricted to those communities.

The 24 plant communities are described using dominant canopy species as the main descriptor. Codes from previous forest classifications that best match the plant communities are listed. The relevant previous classifications referred to are the forest plant communities of Hager and Benson (1994) and the forest types of Forestry Commission of New South Wales (1989). Generally, forest types are much broader in their definition than Hager and Benson (1994) or the classification derived in this survey.

Sites classified into each community are listed. Information on location, physical features and floristics for each sample site is held by the Royal Botanic Gardens. The structural classification follows Walker and Hopkins (1990). The mean number of species recorded in the 20 × 20 m plots per community is given. Indicator species were those species that occurred in > 50% of the sites in a community and had a high fidelity to that group (> 0.8 derived from the fidelity analysis, Bedward unpublished software). The frequency of occurrence of each species in each community is shown in Appendix 1.

A threat status code for the plant communities in the study area have been derived by comparing the area of extant vegetation with an estimate of the pre-European extent (see thresholds in methods section and Table 4). The reservation code is based on percentage protected in reserves compared to an estimate of pre-European extent. The threat and reservation codes given for New South Wales are estimates only based on the authors' knowledge of the distribution and abundance of each plant community over its geographical range.

Community 1: Blakely's Red Gum (*Eucalyptus blakelyi*)-Yellow Box (*Eucalyptus melliodora*) Open Forest (Fig. 12)

Equivalent in Hager and Benson (1994): EF712b&c, EF446c; **Forest Type:** 172, 177

Sample sites (23): 1, 2, 29, 69, 74, 76, 77, 78, 82, 84, 113, 159, 217, 219, 220, 223, 225, 227, 250, 282, 283, 284, 303

Landform: Mainly flats and lower slopes adjoining valleys, occasionally ridges

Substrate: Fine-grained sedimentary rocks such as shale, mudstone and medium nutrient volcanics

Soils: Grey, red or brown clay podsolics

Elevation: 980–1200 m

Distribution: Mainly in the south near Armidale, Old Armidale Road, Boorolong Road, Devils Pinch, Gara River valley and near Thalgarrah

Extant area: native understorey: 4847 ha; exotic understorey: 1765 ha; **Total:** 6612 ha

Estimated remaining extent of pre-European extent: 20%

Structure: Open forest with trees between 12 and 20m with a mid-dense (30–50%) crown cover; shrubs sparse with a mid-dense ground cover

No. native species: 185; **Mean no. per site:** 33 +/- 8.9

No. exotic species: 38; **Mean no. per site:** 5.9 +/- 4.6

Indicator native species: *Eucalyptus blakelyi, Eucalyptus melliodora, Bothriochloa macra*

Common native species:

- Trees: *Eucalyptus blakelyi, Eucalyptus melliodora* with either *Eucalyptus caliginosa, Eucalyptus laevopinea* or *Eucalyptus youmanii*
- Shrubs: *Acacia implexa, Bursaria spinosa, Lissanthe strigosa, Hibbertia linearis, Opercularia aspera, Pimealea curviflora* var. *divergens, Rubus parvifolius*
- Ground cover: *Poa sieberiana, Dichondra repens, Geranium solanderi* var. *solanderi* , *Desmodium varians, Bothriochloa macra, Asperula conferta, Acaena ovina, Themeda australis, Sclerolaena biflorus, Wahlenbergia planifolia* subsp. *planifolia, Austrodanthonia* species

Common exotic species: *Hypochaeris radicata, Rosa rubiginosa, Plantago lanceolata, Paronychia brasiliana, Vulpia myuros, Trifolium* species

Variability: This community includes a small stand of *Eucalyptus moluccana* on Rockvale Road. The stringybark, *Eucalyptus youmanii*, is occasionally

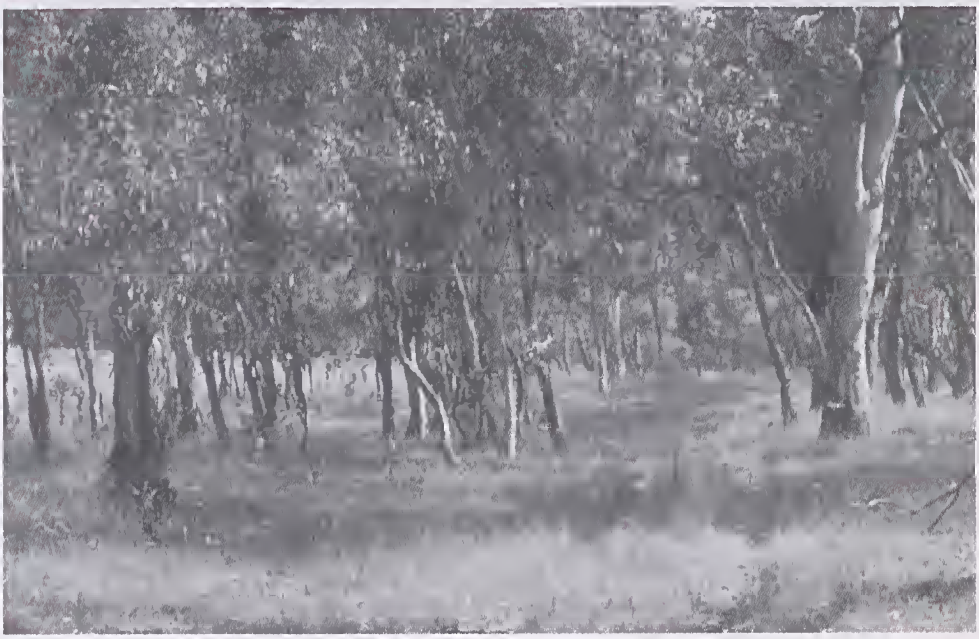

Fig. 12. Community 1 *Eucalyptus blakelyi-Eucalyptus melliodora* open forest on fine-grained sedimentary substrate on a travelling stock reserve near Boorolong west of Armidale.

present. Stringybarks are often common in this community and this community often merges with community 2. Understorey varies depending on grazing pressure and aspect, but contains a suite of grasses, forbs and shrubs.

Condition: Most of the original extent has been cleared, although regrowth occurs in some areas and remnants occur along roadsides and in travelling stock routes. Remnants on private land generally contain a highly modified understorey due to continuous grazing.

Threats: As this community occurs on medium nutrient soils, areas are still prone to clearing. Dieback killed many trees in the 1970s and remains a threat. Understorey of most remnants on private land has been altered by grazing. Exotic pasture species have been sown or have invaded many places.

Threat status: Guyra: E(i), **NSW:** E(i)

Reservation code: Guyra: VP, **NSW:** VP

No. reserves in study area containing this community: 1; **Area reserved:** 1 ha

Conservation status: Small remnants occur on roadsides and on private land, only one hectare is protected in reserves. Reduced to about 20% of its original extent.

Key sites for conservation: Site 84, Rockvale Road TSR near Chandlers Road which has a low grazing pressure and a tablelands occurrence of *Eucalyptus moluccana*. Site 223 roadside on Old Armidale Road. Site 82 adjoining Thalgarrah Field Studies Centre. Site 113, Devils Pinch which contains *Eucalyptus youmanii* in a Crown reserve.

Community 2: Broad-leaved Stringybark (*Eucalyptus caliginosa*) Open Forest (Fig. 13)

Equivalent in Hager and Benson (1994): EF481a,b,c; **Forest Type:** 122

Sample sites (40)**:** 23, 25, 26, 66, 68, 70, 73, 81, 83, 85, 86, 87, 88, 89, 91, 92, 99, 102, 106, 108, 109, 157, 158, 175, 189, 203, 207, 209, 213, 231, 238, 239, 240, 269, 291, 292, 302, 307, 308, 309

Landform, substrate and soils: Mainly confined to ridges and upper slopes on siliceous sedimentary rocks (greywacke), granite and acid volcanics with brown, sandy clay soils.

Distribution: Widely scattered over southern and western sections of the study area. Absent from the granites and leucogranites in the north-east, although *Eucalyptus caliginosa* itself is common as a co-dominant tree in other plant communities on these geologies. It is the most common plant community in the study area.

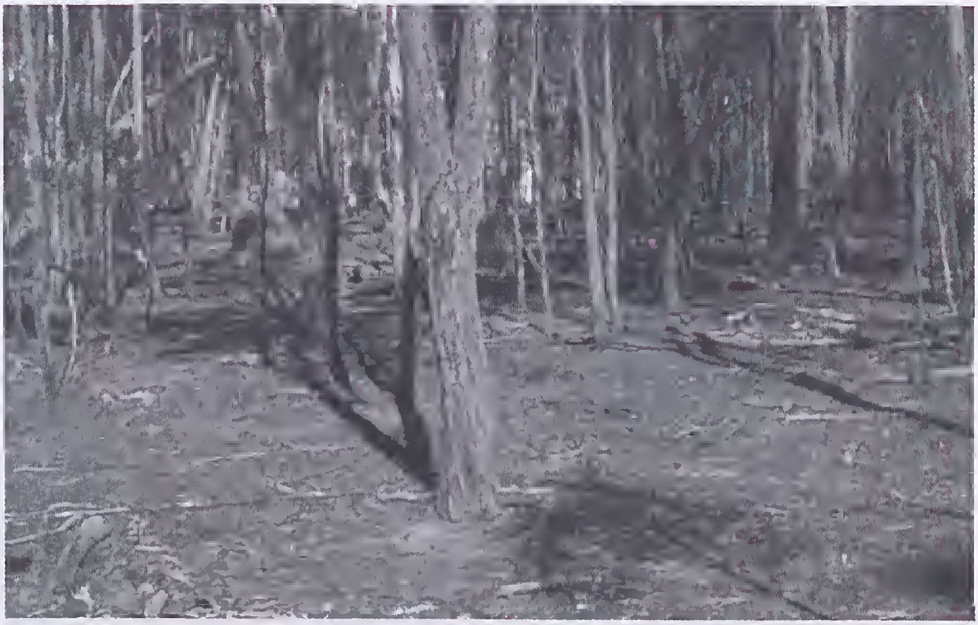

Fig. 13. Community 2, *Eucalyptus caliginosa* open forest is widespread and usually occurs on ridges composed of siliceous sediments. This shows site 68 just east of Armidale, composed of regrowth with a heavily grazed understorey.

Extant area: native understorey: 9844 ha; exotic understorey: 1302 ha; **Total:** 11 146 ha

Estimated remaining extent of pre-European extent: 60% (mainly regrowth)

Structure: Open forest, trees 15–25 m high with a mid-dense (30–50%) crown cover, some regrowth areas have a dense (50–80%) crown cover. Shrubs sparse, ground cover sparse, to mid-dense

No. native species: 212; **Mean no. per site:** 30 +/- 7

No. exotic species: 41; **Mean no. per site:** 7 +/- 4

Common native species:

- Trees: *Eucalyptus caliginosa* with either *Eucalyptus melliodora*, *Eucalyptus blakelyi*, *Eucalyptus bridgesiana*, *Eucalyptus viminalis*
- Shrubs: *Lissanthe strigosa*, *Melichrus urceolatus*, *Hibbertia linearis*, *Acacia implexa*
- Ground cover: *Geranium solanderi* var. *solanderi*, *Dichondra repens*, *Poa sieberiana*, *Glycine clandestina*, *Scleranthus biflorus*, *Poranthera microphylla*, *Rumex brownii*, *Veronica calycina*, *Hypericum gramineum*

Indicator native species: *Eucalyptus caliginosa*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Paronychia brasiliana*, *Taraxacum officinale*, *Rosa rubiginosa*

Variability: Very variable with low species fidelity compared to some other communities. The closely related community 19 occurs along Rockvale Road north-east of Armidale and is dominated by *Eucalyptus acaciiformis*.

Condition: Extensively cleared and now mainly regrowth. Understorey often heavily grazed but the stringybark trees are less affected by dieback than other tree species. Some fenced off areas have denser shrub layers.

Threats: Due to this community occurring on ridges and poorer soils, it is less threatened than valley communities and many areas have regrown after clearing in the early 20th century.

Threat status: Guyra: LC (i); **NSW:** LC(i)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 2; **Area reserved:** 443 ha

Conservation status: Represented in Mount Duval and Boorolong Nature Reserves.

Key sites for conservation: Site 92 roadside reserve on Eastview Road, site 95 along Rockvale Road near 'Tarrangower', site 309 'Caer Timvil' off New England Highway, site 175 Wandsworth Road near 'Glen Park', site 213 Little Mount Duval.

Community 3: Silver-top Stringybark (*Eucalyptus laevopinea*) Open Forest (Fig. 14)

Equivalent in Hager and Benson (1994): EF479a,c; **Forest Type:** 167

Sample sites (41): 28, 71, 72, 75, 79, 90, 94, 104, 105, 111, 112, 114, 161, 176, 188, 190, 195, 196, 197, 198, 199, 200, 201, 202, 204, 205, 206, 208, 224, 226, 228, 229, 230, 237, 248, 249, 285, 286, 294, 301, 304

Landform, substrate and soils: Often occurs on steep escarpment slopes and often on rich soils such as those derived from basalt — but also occurs on sedimentary, acid volcanic and granitic substrates. At elevations 970–1300 m.

Distribution: Widespread on different substrates from near Armidale and Mount Duval in the south-west, Black Mountain to Ben Lomond in the central-west and Lagune Sugarloaf in the east.

Structure: Open forest with trees 12–25 m high, generally mid-dense (30–50%) crown cover but more dense in some regrowth stands. Sparse to mid-dense shrub layer (10–50% cover); mid-dense to dense ground cover (30–80 %) cover.

Extant area: native understorey: 9000 ha; exotic understorey: 1084 ha; **Total:** 10 084 ha

Estimated remaining extent of pre-European extent: 50% (much is regrowth)

No. native species: 205; **Mean no. per site:** 32 +/- 8

No. exotic species: 50; **Mean no. per site:** 6 +/- 4

Common native species:

- Trees: *Eucalyptus laevopinea* commonly with *Eucalyptus melliodora*, *Eucalyptus bridgesiana*, *Eucalyptus dalrympleana* subsp. *heptantha*, *Angophora floribunda*
- Shrubs: *Bursaria spinosa*, *Lissanthe strigosa*, *Acacia dealbata*, *Hibbertia linearis*
- Ground cover: *Poa sieberiana*, *Dichondra repens*, *Glycine clandestina*, *Veronica calycina*, *Desmodium varians*, *Geranium solanderi* var. *solanderi*, *Acaena novae-zelandiae*, *Hydrocotyle laxiflora*, *Elymus scaber*

Indicator native species: The fidelity analysis did not identify any indicator species for this community reflecting that it contains species that commonly occur in other communities.

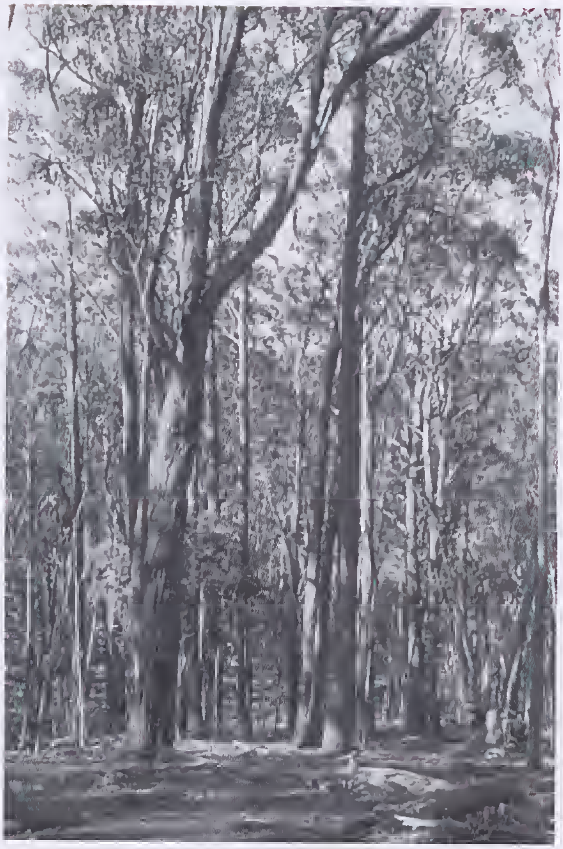

Fig. 14. Community 3, *Eucalyptus laevopinea* open forest is common on slopes and ridges composed of fine-grained sedimentary, basalt or acid volcanic rocks. Trees are over 20 m high at site 105 shown here in Boorolong Nature Reserve.

Common exotic species: *Hypochaeris radicata, Vulpia myuros, Taraxacum officinale, Paronychia brasiliana, Cirsium vulgare*

Variability: A number of subgroups are geographically based, for example, the sites on Mount Duval are floristically similar to each other.

Condition: Mostly cleared. Most remnants are 50 year + regrowth. The understorey is generally in poor condition except in areas protected from excessive grazing–for example Mount Duval.

Threats: Clearing (including ringbarking) threatens areas on better soils such as basalt, although in some places trees are regrowing from past clearing, particularly on steep slopes. The understorey of most remnants on private land is degraded due to heavy grazing.

Threat status: Guyra: NT(i), **NSW** NT(i)

Reservation code: Guyra: P, **NSW:** P

No. reserves in study area containing this community: 2; **Area reserved:** 373 ha

Conservation status: This community is inadequately reserved, but is represented in the newly dedicated Mount Duval and Boorolong Nature Reserves, and is on Crown land at Devils Pinch.

Key sites for conservation: Crown land at Thunderbolts Cave near Devils Pinch (site 28).

Community 4: Tenterfield Woollybutt *(Eucalyptus banksii)*-Silver-top Stringybark *(Eucalyptus laevopinea)* Open Forest (Fig. 15)

Equivalent in Hager and Benson (1994): EF507c; **Forest Type:** nil

Sample sites (8)**:** 80, 103, 110, 297, 299, 300, 305, 306

Landform, substrate and soils: Steep, rocky upper slopes or ridges on acid volcanic or sedimentary substrates with grey clay soils. At elevations 1140–1270 m.

Distribution: Restricted to a few locations. In the south-western part of the study area it occurs in the Devils Pinch-Black Mountain region. Present on Little Duval, and on higher peaks of Boorolong Nature Reserve. Most common on the acid volcanic substrate of the western part of the study area, for example near Abington Creek.

Extant area: native understorey: 328 ha; exotic understorey: 9 ha; **Total:** 337 ha

Estimated remaining extent of pre-European extent: 70%

Structure: Trees 10–20 m high, with a mid-dense to dense (30–80%) crown cover; sparse or no shrub layer; sparse to mid-dense ground cover.

No. native species: 87; **Mean no. per site:** 30 +/- 10

No. exotic species: 17; **Mean no. per site:** 2 +/- 1

Common native species:

- Trees: *Eucalyptus banksii*, *Eucalyptus laevopinea*
- Shrubs: *Olearia viscidula*, *Opercularia aspera*, *Hibbertia linearis*, *Lissanthe strigosa*
- Ground cover: *Poa sieberiana*, *Poranthera microphylla*, *Lomandra filiformis* subsp. *coriacea*, *Dichelachne micrantha*. *Joycea pallida* formed a dense grass cover at two sites.

Indicator native species: *Eucalyptus banksii*, *Eucalyptus laevopinea*, *Olearia viscidula*, *Lomandra filiformis* subsp. *coriacea*

Common exotic species: *Hypochaeris radicata*

Variability: Little variation. Some understorey differences between sites such as the presence of *Joycea pallida*.

Condition: Relatively good, few weeds, due to its location on siliceous substrates and rocky ground. Fenced-off areas have a more dense understorey than areas subjected to grazing by stock.

Threats: Main threats are grazing of the understorey and cutting trees for firewood.

Threat status: Guyra: NT(ii); **NSW:** NT(ii)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 13 ha

Reservation status: Poorly conserved — a small patch is reserved in Boorolong Nature Reserve.

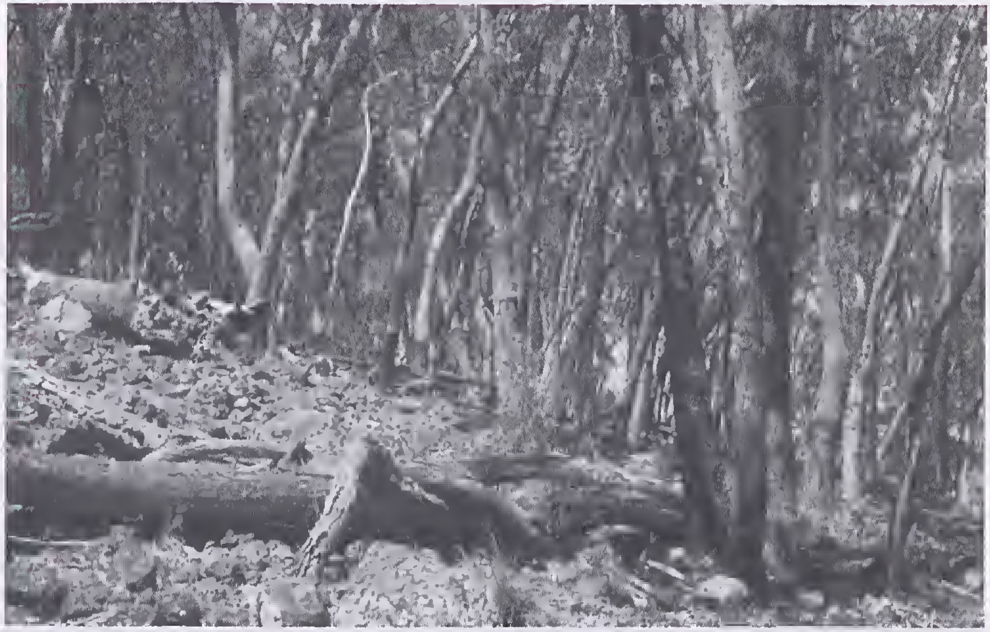

Fig. 15. Community 4, *Eucalyptus banksii-Eucalyptus laevopinea* mainly occurs on upper slopes on acid volcanic rocks. It also occurs on siliceous sedimentary rocks such as this stand at site 110 on an escarpment 20 km north of Armidale.

Key sites for conservation: Site 80 on Sunnyside Road where the tufted grass *Joycea pallida* dominates the ground layer. Also sites 299 and 306 on acid volcanic substrate in the Abington Creek region.

Community 5: Youman's Stringybark (*Eucalyptus youmanii*)-Western New England Blackbutt (*Eucalyptus andrewsii*)-*Eucalyptus subtilior* +/- Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) Open Forest (Fig. 16)

Equivalent in Hager and Benson (1994): EF486a; **Forest Type:** 122

Sample sites (17)**:** 8, 9, 12, 13, 14, 160, 177, 178, 179, 215, 221, 287, 288, 289, 290, 295, 298

Landform, substrate and soils: Ridges and slopes on acid volcanic substrates with yellow-brown clays.

Distribution: North-west of Guyra including Happy Valley, Wandsworth Road, Whans Road, Elderberry Creek at elevations 1110–1320 m.

Extant area: native understorey: 3154 ha; exotic understorey: 176 ha; **Total:** 3330 ha

Estimated remaining extent of pre-European extent: 15%

Structure: Open forest with trees 12–18 m high and with a mid-dense to dense (30–80%) crown cover, very sparse shrub layer and sparse ground cover.

No. native species: 173; **Mean no. per site:** 31 +/- 9

No. exotic species: 29; **Mean no. per site:** 4 +/- 5

Common native species:

- Trees: *Eucalyptus andrewsii*, *Eucalyptus youmanii*, *Eucalyptus subtilior*, *Eucalyptus caliginosa*, *Eucalyptus dalrympleana* subsp. *heptantha*, *Eucalyptus nicholii*, with a subgroup containing *Eucalyptus prava* on ridges in one area
- Shrubs: *Melichrus urceolatus*, *Hibbertia linearis*, *Hovea linearis*, *Pultenaea campbellii*
- Ground cover: *Poranthera microphylla*, *Oxalis radicosa*, *Hardenbergia violacea*, *Gonocarpus tetragynus*, *Dichondra repens*, *Dichelachne micrantha*, *Poa sieberiana*, *Goodenia hederacea* subsp. *hederacea*

Indicator native species: *Eucalyptus andrewsii*, *Goodenia bellidifolia* subsp. *bellidifolia*, *Oxalis radicosa*

Common exotic species: *Hypochaeris radicata*, *Aira elegantissima*, *Trifolium repens*

Variability: This community is defined by its understorey. The sites are pulled together in the floristic analysis due mainly to the sharing of common understorey species growing on acid volcanic soils in the drier, western part of the study area. There is considerable variation in tree species

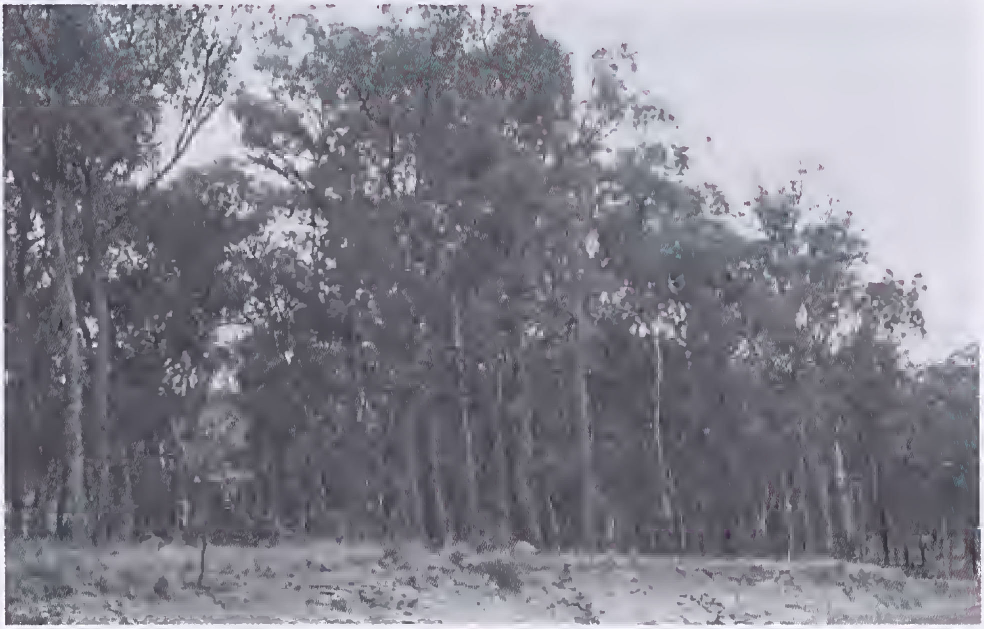

Fig. 16. Community 5, at site 14 adjacent to the Guyra-Tingha Road containing *Eucalyptus subtilior*, *Eucalyptus andrewsii* and *Eucalyptus caliginosa* on acid volcanic rock.

depending on the landform position (high slope to lower slopes). For example, *Eucalyptus nicholii*, *Eucalyptus youmanii* and *Eucalyptus dalrympleana* subsp. *heptantha* tend to grow on lower slopes or flatter terrain (most of which has been cleared). In contrast, *Eucalyptus prava* and *Eucalyptus andrewsii* occur on shallow soils on rocky steeper-sloped terrain (much of which remains uncleared). It is likely that further sampling to the west of the study area would yield data that would warrant splitting this community.

Condition: Lower slopes mainly cleared, large remnants on rocky ridges persist.

Threats: Most of the occurrences of this community on lower slopes or flat terrain have been cleared for grazing. Subdivision and hobby farms threaten larger remnants in rocky terrain. Heavy grazing of remnant understorey and firewood cutting are the main threats.

Threat status: Guyra E(i); **NSW:** E(i)

Reservation code: Guyra VP; **NSW:** P

No. reserves in study area containing this community: 0; **Area reserved:** 0

Reservation status: The recent dedication of Single State Forest as Single Nature Reserve to the west of the study area protects a sample of this threatened plant community. Parts of Kings Plains National Park and Torrington State Recreation Area sample vegetation that is similar. This community is not protected in reserves in the study area.

Key sites for conservation: A number of sites are important due to degree of clearing of the community and the presence of the rare species (*Eucalyptus nicholii*): Sites 12 and 13 along Wandsworth Road, site 14 TSR on Tingha Road north of Wandsworth, sites 288, 289 and 290 near Reedy Creek, site 215 Fleetwood Road west of Boorolong, site 178 Happy Valley.

Community 6: Ribbon Gum (*Eucalyptus viminalis*)-Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*)-Snow Gum (*Eucalyptus pauciflora*) Open Forest-Tall Open Forest with a Grassy Understorey on Basalt (Fig. 17)

Equivalent in Hager and Benson (1994): EF415b; **Forest Type:** 159

Sample sites (17): 6, 7, 10, 11, 30, 31, 46, 155, 156, 180, 181, 182, 185, 186, 187, 253, 310

Landform, substrate and soils: Mainly confined to the high undulating, basalt plateau centred on Guyra with deep, chocolate or krasnozem loam soils. Numerous swampy depressions are present on the plateau.

Distribution: Extending along the spine of the Great Dividing Range at high elevations (1200–1500 m), from Ben Lomond in the north to Black Mountain in the south. Outlying occurrences occur on Mount Mitchell in the north-east and near Armidale in the south.

Extant area: native understorey: 3119 ha; exotic understorey: 3524 ha; **Total:** 6643 ha

Estimated remaining extent of pre-European extent: 15%

Structure: Open forest to tall open forest. Trees mainly about 20 m high but up to 30 m. Mid-dense cover (30–50%); shrub layer is very sparse (10%) and ground cover is dense or very dense (50–100%) and dominated by grass species.

No. native species: 155; **Mean no. per site:** 32.9 +/- 9

No. exotic species: 50; **Mean no. per site:** 10 +/- 5.2

Common native species:

- Trees: *Eucalyptus viminalis*, *Eucalyptus dalrympleana* subsp. *heptantha*, *Eucalyptus pauciflora* occasionally *Eucalyptus stellulata*
- Shrubs: *Acacia dealbata*, *Pultenaea microphylla*, *Pimelea linifolia*
- Ground cover: *Geranium solanderi* var. *solanderi*, *Hydrocotyle laxiflora*, *Glycine clandestina*, *Rubus parvifolius*, *Asperula conferta*, *Themeda australis*, *Poa sieberiana*, *Poa labillardieri*, *Acaena novae-zelandiae*, *Acaena ovina*, *Viola betonicifolia*, *Dichondra repens*, *Wahlenbergia stricta* subsp. *stricta*, *Bracteantha bracteata*, *Desmodium varians*, *Scleranthus biflorus*, *Diuris abbreviata*, *Galium ciliare*, *Hypericum gramineum*, *Ranunculus lappaceus*

Indicator native species: *Eucalyptus viminalis*, *Ranunculus lappaceus*, *Pultenaea microphylla*, *Ammobium alatum*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Cirsium vulgare*, *Taraxacum officinale*, *Petrorhagia nanteuilii*

Variability: Community 6 is similar to community 7 in the floristic composition of the understorey. The tall forest of *Eucalyptus viminalis* and *Eucalyptus dalrympleana* subsp. *heptantha* would have originally dominated much of the basalt plateau and is now only surviving in small remnants. *Eucalyptus pauciflora* is more common on the highest (coldest) ridges and in cold air drainage valleys.

Condition: Poor. Mostly cleared with less than 10% of this community remaining and much of that is regrowth or has had its understorey adversely

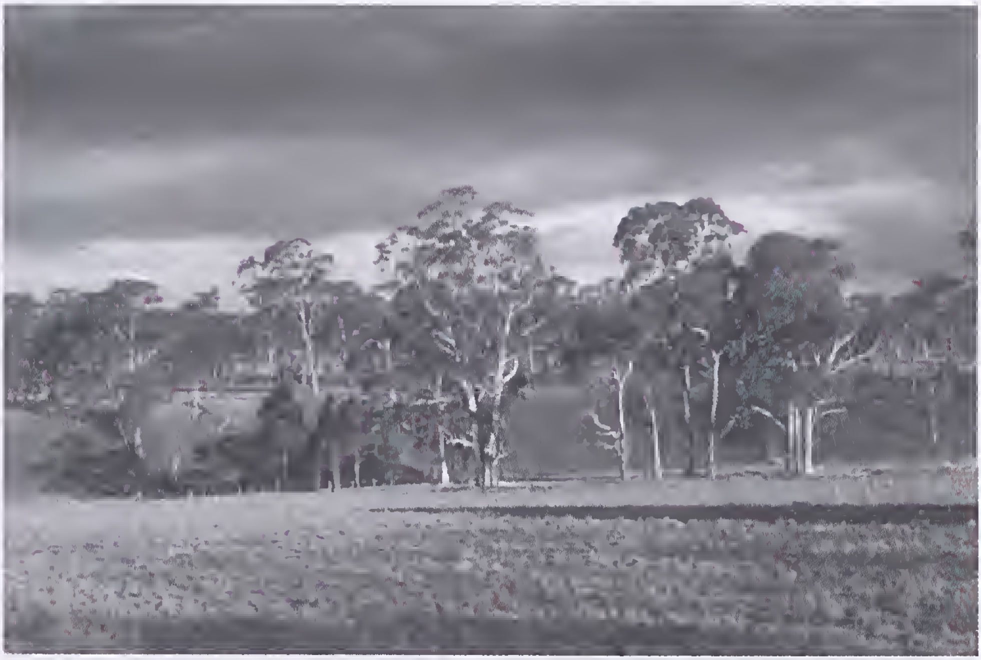

Fig. 17. Community 6, *Eucalyptus viminalis-Eucalyptus dalrympleana* subsp. *heptantha* on undulating basalt plateau near Guyra. Less than 15% of this forest type is estimated to remain uncleared and most remnants are in poor condition.

affected by grazing or weed invasion. The best remnants are along roadsides such as the New England Highway.

Threats: An endangered plant community threatened by further clearing of remnants, grazing of understorey and weed invasion.

Threat status: Guyra: E(i); **NSW:** E(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 1; **Area reserved:** 17 ha

Conservation status: Small area held in Llangothlin Nature Reserve.

Key sites for conservation: Site 10 Crown reserve south of Ben Lomond on Wandsworth Road; the road reserve (including sites 6 and 7) on the New England Highway; site 155 on Baldersleigh Road (which has a population of the rare plant *Thesium australe)*; sites 180, 181 and 182 along Aberfoyle Road for *Thesium australe*; sites 186 and 187 on the top of Mount Ben Lomond; and site 310 on the ridge above the Lagoon Farm wetland.

Community 7: Black Sallee (*Eucalyptus stellulata*)-Snow Gum (*Eucalyptus pauciflora*) Low Open Forest or Low Open Woodland with a grassy understorey

Equivalent in Hager and Benson (1994): EF412a; **Forest Type:** 137

Note: Community 7 has a lower canopy height (< 12 m) than community 6 and is dominated by Black Sallee while community 6 is a taller (> 12 m) forest dominated by Ribbon Gum or Mountain Gum. The two communities were distinguished for the vegetation map through aerial photographic interpretation and field traverse.

Sample sites (4): 184, 194, 251, 254

Landform, substrate and soils: Mainly confined to the high undulating, basalt plateau centred on Guyra with deep, chocolate or krasnozem loam soils. Often on valley sides or swampy depressions. Sometimes on other soil types.

Distribution: Mainly confined to the Guyra plateau from Ben Lomond in the north to Black Mountain in the south.

Extant area: native understorey: 606 ha; exotic understorey: 1213 ha; **Total:** 1819 ha

Estimated remaining extent of pre-European extent: 10%

Structure: Low open forest or low woodland with trees less then 12m high and generally with a mid-dense to open crown cover (10–50%).

No. native species: 86; **Mean no. per site:** 34.5 +/-6.2

No. exotic species: 28; **Mean no. per site:** 12 +/- 4.7

Common native species:

- Trees: *Eucalyptus stellulata*, *Eucalyptus pauciflora*
- Shrubs: *Acacia dealbata*, *Pultenaea microphylla*, *Pimelea linifolia*
- Ground cover: *Geranium solanderi* var. *solanderi*, *Hydrocotyle laxiflora*, *Glycine clandestina*, *Rubus parvifolius*, *Asperula conferta*, *Poa sieberiana*, *Acaena novae-zelandiae*, *Dichondra repens*, *Hypericum gramineum*, *Scleranthus biflorus*, *Wahlenbergia stricta* subsp. *stricta*

Indicator native species: *Eucalyptus stellulata*, *Ammobium alatum*

Common exotic species: *Acetosella vulgaris*, *Hypochaeris radicata*, *Trifolium repens*, *Cirsium vulgare*, *Taraxacum officinale*, *Rubus ulmifolius*

Variability: Crown cover varies considerably depending on degree of thinning or regrowth.

Condition: Poor. Mostly cleared with less than 10% of this community remaining and much of that is regrowth or has had its understorey altered by grazing or pasture weed invasion.

Threats: An endangered plant community threatened by further clearing of remnants, grazing of understorey and weed invasion.

Threat status: Guyra: E(i); **NSW:** V(i)

Reservation code: Guyra: VP; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 27 ha

Conservation status: Small area held in Llangothlin Nature Reserve.

Community 8: New England Peppermint (*Eucalyptus nova-anglica*) Woodland on Basalt (Fig. 18)

Equivalent in Hager and Benson (1994): EF517a; **Forest Type:** 142

Sample sites: not sampled-nearly extinct.

Landform, substrate and soils: Base of valleys on basalt plateaux.

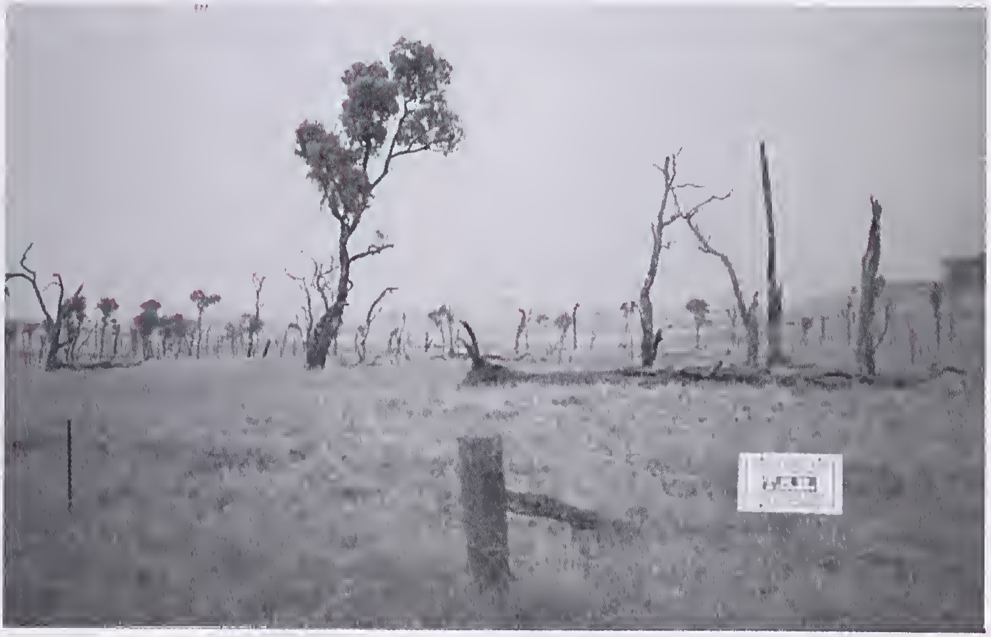

Fig. 18. Community 8, affected by dieback. New England Peppermint *Eucalyptus nova-anglica* on basalt (community 8) near Guyra. This community has been extensively cleared and only a few patches remain.

Distribution: Mainly confined to the basalt plateau around Guyra.

Extant area: native understorey: 172 ha; exotic understorey: 173 ha; **Total:** 345 ha

Estimated remaining extent of pre-European extent: 5%

Structure: Woodland, tree height varies from 8–20 m with a sparse (up to 30%) cover. Few shrubs are present but ground cover is usually dense.

No. native species: NA; **Mean no. per site:** NA

No. exotic species: NA; **Mean no. per site:** NA

Common native species:

- Trees: *Eucalyptus nova-anglica*
- Shrubs: No common shrubs
- Ground cover: *Poa sieberiana, Asperula conferta* and other grasses and forbs

Indicator native species: NA

Common exotic species: NA

Variability: NA

Condition: Nearly extinct. Almost entirely cleared and what remains has been affected by dieback and the understorey has been heavily grazed.

Threats: A critically endangered plant community threatened by further clearing of remnants, dieback, grazing of understorey, weed invasion.

Threat status: Guyra: CE(i); **NSW:** CE(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved

Key sites for conservation: Few remnants remain. Patches occur along Wards Mistake and Handebos Roads east of Guyra township.

Community 9: New England Peppermint (*Eucalyptus nova-anglica*) Woodland on Sediments (Fig. 19)

Equivalent in Hager and Benson (1994): EF517a; **Forest Type:** 142

Sample sites (7): 15, 67, 93, 96, 191, 216, 222

Landform, substrate and soils: Valley flats subject to cold air drainage composed of fine-grained sedimentary and acid volcanic substrates with poorly drained loam-clay soils.

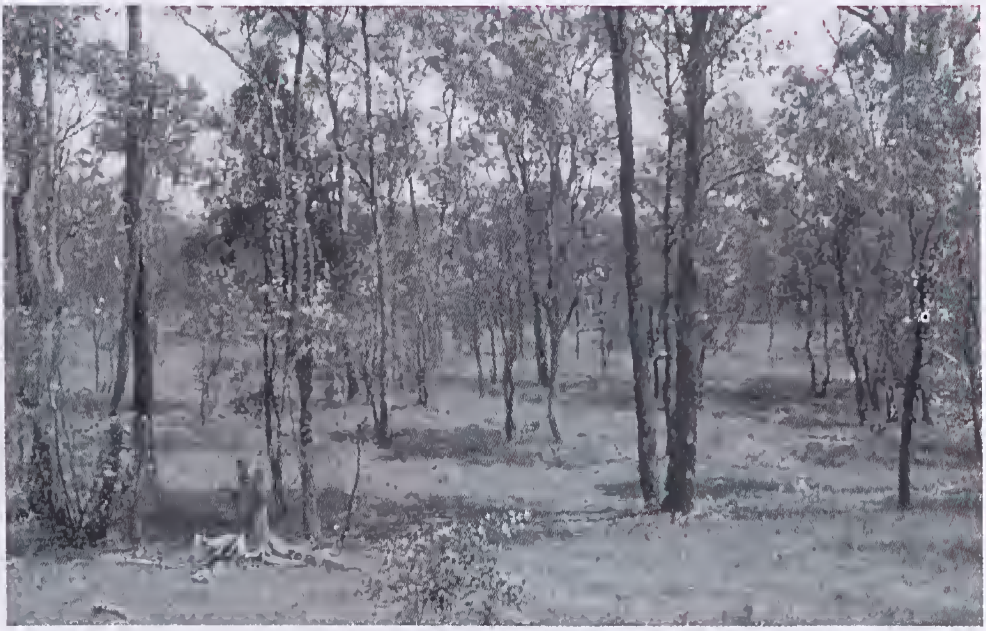

Fig. 19. Community 9, *Eucalyptus nova-anglica* regrowth woodland on sedimentary rock at site 67, 5 km to the east of Armidale. This woodland has been severely affected by dieback over the last two decades.

Distribution: Mainly confined to the southern section of the study area near Armidale and Boorolong, and in the western section on the Tingha Road near Wandsworth; at elevations 900–1180 m.

Extant area: native understorey: 1167 ha; exotic understorey: 812 ha; **Total:** 1979 ha

Estimated remaining extent of pre-European extent: 15%

Structure: Woodland, tree height varies from 8–20 m with a sparse (up to 30%) cover. Few shrubs are present but ground cover is usually dense.

No. native species: 94; **Mean no. per site:** 27 +/- 3

No. exotic species: 29; **Mean no. per site:** 9 +/- 7

Common native species:

- Trees: *Eucalyptus nova-anglica* occasionally with *Eucalyptus dalrympleana* subsp. *heptantha*
- Shrubs: No common shrubs
- Ground cover: *Asperula conferta*, *Themeda australis*, *Juncus filicaulis*, *Dichondra repens*, *Carex inversa*, *Rumex brownii*, *Acaena ovina*, *Desmodium varians*

Indicator native species: *Eucalyptus nova-anglica*, *Carex inversa*, *Haloragis heterophylla*, *Juncus filicaulis*, *Cymbonotus lawsonianus*, *Leucopogon fraseri*

Common exotic species: *Hypochaeris radicata*, *Aira elegantissima*, *Rosa rubiginosa*

Variability: Variation is present in structure due to stages of regrowth after clearing or dieback.

Condition: Poor. Mostly cleared and what remains has been severely affected by dieback and the understorey has been heavily grazed.

Threats: An endangered plant community threatened by further clearing of remnants, dieback, grazing of understorey, weed invasion.

Threat status: Guyra: E(i); **NSW:** E(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 2; **Area reserved:** 54 ha

Conservation status: Small areas are sampled in Duval and Boorolong Nature Reserves. Remnants also occur in some TSRs and road reserves.

Key sites for conservation: Sites 15 and 191 on Tingha Road, site 93 Rockvale Road at Wollomombi River, site 67 also on Rockvale Road.

Community 10: New England Peppermint (*Eucalyptus nova-anglica*)-Snow Gum (*Eucalyptus pauciflora*) Open Forest on Granite and Leucogranite (Fig. 20)

Equivalent in Hager and Benson (1994): EF517b; **Forest Type:** 142

Sample sites (9): 17, 22, 37, 44, 115, 140, 143, 235, 246

Landform, substrate and soils: Flats and lower slopes subject to cold air drainage, on granite and leucogranite substrates with poorly drained yellow-brown sandy loam soils.

Distribution: North-eastern section of the study area including Backwater, Sara River, Oban River at elevations 980–1280 m.

Extant area: native understorey: 4040 ha; exotic understorey: 418 ha; **Total:** 4458 ha

Estimated remaining extent of pre-European extent: 25%

Structure: Open forest, trees 18 m high with a mid-dense (30–50%) cover with a sparse shrub cover but with tall grasses or bracken (*Pteridium esculentum*), and a dense ground cover.

No. native species: 126; **Mean no. per site:** 35 +/- 9

No. exotic species: 28; **Mean no. per site:** 6 +/- 2

Common native species:

- Trees: *Eucalyptus nova-anglica*, *Eucalyptus pauciflora*, *Eucalyptus stellulata*
- Shrubs: *Rubus parvifolius*, *Bursaria spinosa*, *Leucopogon fraseri*
- Ground cover: *Themeda australis*, *Pteridium esculentum*, *Glycine clandestina*, *Acaena novae-zelandiae*, *Scleranthus biflorus*, *Hypericum gramineum*, *Poa sieberiana*, *Imperata cylindrica*

Indicator native species: *Eucalyptus stellulata*, *Eucalyptus pauciflora*, *Grevillea juniperina*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Acetosella vulgaris*, *Holcus lanatus*

Variability: Forest height varies, being taller along the Oban River where Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) is present. There is also more *Pteridium* and *Imperata* along the Oban River, perhaps indicating more frequent fire in that area.

Condition: Poor. Mostly cleared and only small remnants remain. Dieback has severely impacted on this community.

Threats: Further clearing and dieback, tin-mining and grazing of remnants. Not reserved and one of the most endangered plant communities on the New England Tableland.

Threat status: Guyra: E(i); **NSW:** E(i)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 1; **Area reserved:** 2 ha

Conservation status: Tiny portion of this community is within Warra National Park.

Key sites for conservation: Site 235 near Granite Springs, site 143 adjacent to Oban River, site 22 Wards Mistake Road, site 37 Sara River.

Community 11: Broad-leaved Stringybark (*Eucalyptus caliginosa*)-Mountain Gum (*Eucalyptus dalrympleana* subsp. *heptantha*) Open Forest on Leucogranite (Fig. 21)

Equivalent in Hager and Benson (1994): EF413c; **Forest Type:** nil

Sample sites (13): 3, 20, 33, 41, 55, 58, 60, 64, 65, 256, 261, 264, 265

Landform, substrate and soils: Flats and lower slopes on leucogranite substrate with sandy, low nutrient soil.

Distribution: Confined to the north-eastern section of the study area between Backwater, Mount Mitchell and Paddys Gully Road at elevations 1020–1240 m.

Extant area: native understorey: 4356 ha; exotic understorey: 41 ha; **Total:** 4397 ha

Estimated remaining extent of pre-European extent: 60%

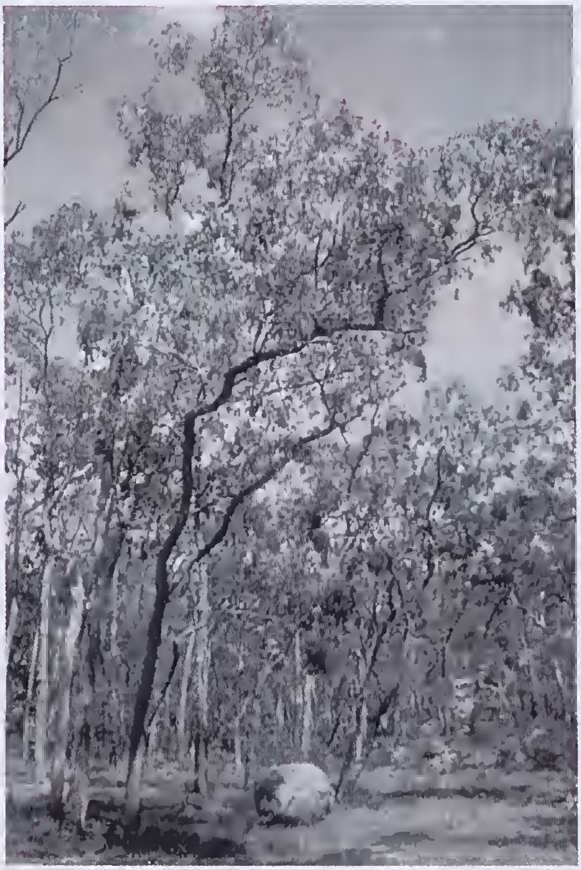

Fig. 20. Community 10, on leucogranite on the property Wattleridge near Backwater showing New England Peppermint (*Eucalyptus nova-anglica*).

Structure: Open forest, trees 20 m mid-dense-dense (30–80%) crown cover. One to several shrub layers present, sparse to mid-dense. Ground cover sparse to mid-dense.

No. native species: 168; **Mean no. per site:** 42 +/- 7

No. exotic species: 4; **Mean no. per site:** 1.4 +/- 0.8

Common native species:

- Trees: *Eucalyptus caliginosa*, *Eucalyptus dalrympleana* subsp. *heptantha* occasionally *Eucalyptus radiata* subsp. *sejuncta*
- Shrubs: *Persoonia cornifolia*, *Bossiaea scortechinii*, *Acacia filicifolia*, *Opercularia hispida*, *Hovea linearis*, *Banksia integrifolia* subsp. A, *Rubus parvifolius*, *Brachyloma daphnoides*
- Ground cover: *Pteridium esculentum*, *Goodenia hederacea* subsp. *hederacea*, *Themeda australis*, *Stylidium graminifolium*, *Gonocarpus tetragynus*, *Dichelachne micrantha*, *Imperata cylindrica*

Indicator native species: *Eucalyptus dalrympleana* subsp. *heptantha*, *Bossiaea scortechinii*, *Hovea linearis*, *Stylidium graminifolium*

Common exotic species: *Hypochaeris radicata*

Variability: Little variation in species mix. Site 20 on Paddys Gully Road lacks *Eucalyptus dalrympleana* subsp. *heptantha* and contains *Jacksonia scoparia* as an understorey dominant.

Condition: While clearing has eliminated some areas, intact patches remain that are in good condition lacking weeds and have not been affected by dieback.

Threats: The main threat is the continual clearing of this marginal agricultural land by traditional and hobby farmers, although this community is less threatened than communities 8, 9 and 10.

Threat status: Guyra: NT(i); **NSW**: LC(i)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 56 ha

Conservation status: Poorly represented in reserves but it is sampled in Warra National Park.

Key sites for conservation: Most sites are in good condition and warrant protection. Of particular importance are sites 55 and 261 on 'Wattleridge' and sites 58 and 256 on portion 14, Parish of Hall, County Clarke. These two properties contain the largest and most intact vegetation remnant in the study area. They contain outstanding conservation values for a number of plant communities and rare plant species.

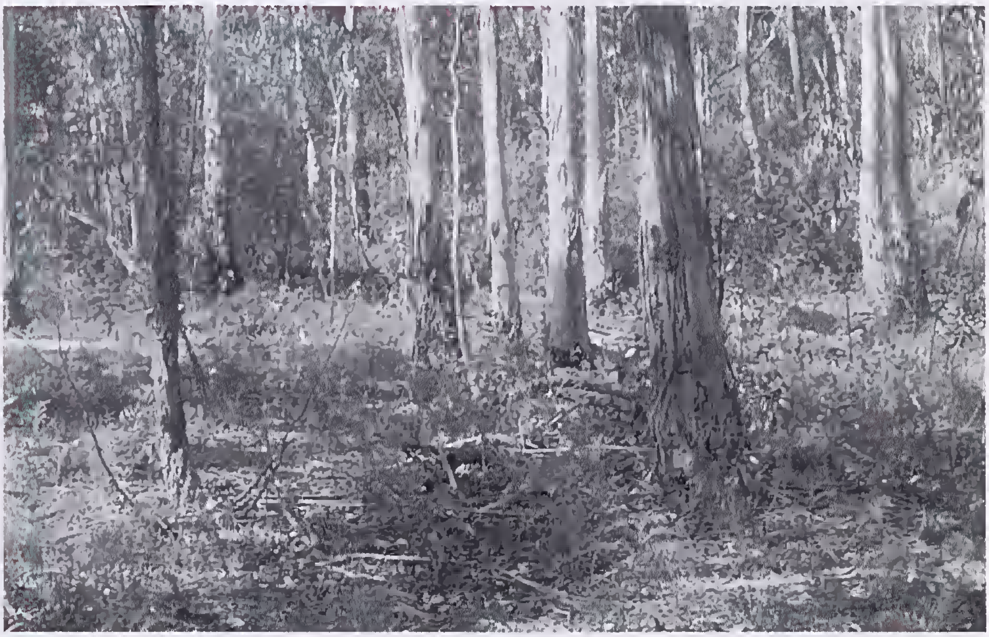

Fig. 21. Community 11, *Eucalyptus caliginosa-Eucalyptus dalrympleana* subsp. *heptantha* on flats on leucogranite at site 41 in Warra State Forest northeast of Backwater.

Community 12: New England Blackbutt (*Eucalyptus campanulata*) Open Forest on Leucogranite (Fig. 22).

Equivalent in Hager and Benson (1994): EF505a,b,c; **Forest Type:** 163

Sample sites (18)**:** 19, 54, 57, 62, 63, 116, 120, 129, 133, 233, 234, 236, 242, 243, 244, 258, 259, 260

Landform, substrate and soils: Rocky ridges and upper slopes on leucogranite with shallow, low nutrient, sandy soils.

Distribution: Confined to the leucogranite outcrop north-east of Backwater at elevations 1100–1300 m.

Extant area: native understorey: 2118 ha; exotic understorey: 0 ha; **Total:** 2118 ha

Estimated remaining extent of pre-European extent: 90%

Structure: Open forest, trees 15–20 m high mid-dense (30–50%) crown cover. Very sparse, small tree layer of *Allocasuarina littoralis* often present. Shrub and ground layers sparse to mid dense.

No. native species: 161; **Mean no. per site:** 34 +/-8.0

No. exotic species: 6; **Mean no. per site:** 0.5 +/-0.8

Common native species:

- Trees: *Eucalyptus campanulata* with *Eucalyptus caliginosa* or *Eucalyptus radiata* subsp. *sejuncta*
- Shrubs: *Lomatia silaifolia*, *Allocasuarina littoralis*, *Persoonia cornifolia*, *Monotoca scoparia*, *Brachyloma daphnoides*, *Banksia integrifolia* subsp. A
- Ground cover: *Goodenia hederacea* subsp. *hederacea*, *Gonocarpus tetragynus*, *Pteridium esculentum*, *Entolasia stricta*, *Poranthera microphylla*

Indicator native species: *Eucalyptus campanulata*, *Eucalyptus cameronii*, *Pomax umbellata*, *Patersonia sericea*, *Allocasuarina littoralis*

Common exotic species: *Hypochaeris radicata*

Variability: Associate tree species vary, for example at site 260 on 'Wattleridge', *Eucalyptus acaciiformis* is dominant. Understorey varies with aspect and fire history, for example site 242 upslope from Backwater Creek is dominated by the fern *Gleichenia dicarpa*. Some large leucogranite boulders provide habitat for ferns.

Condition: Good condition. Little affected by clearing due to its presence on rough terrain. Very few weeds.

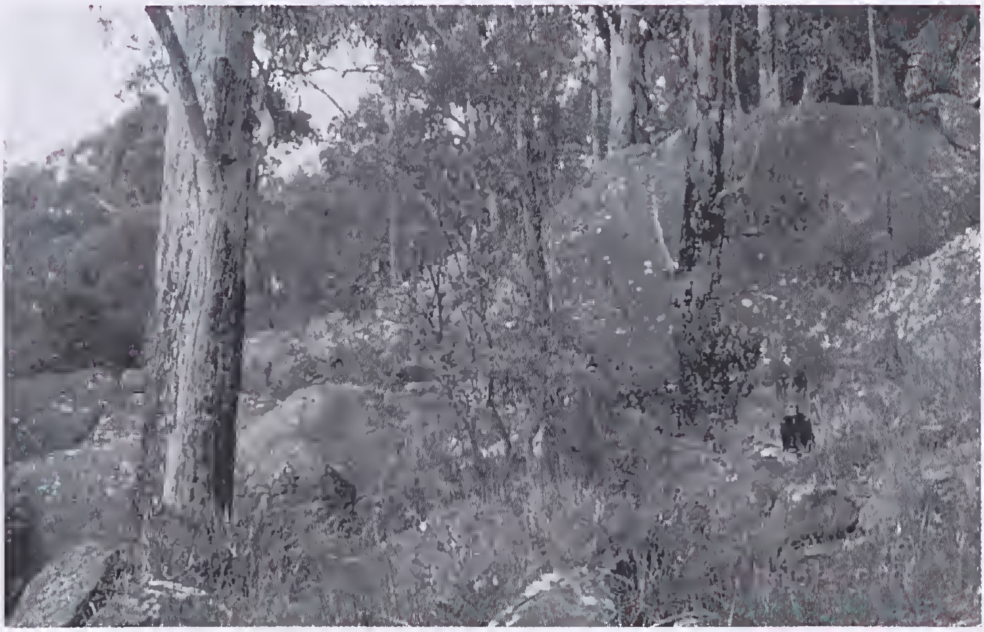

Fig. 22. Community 12, dominated by *Eucalyptus campanulata*, commonly occurs on leucogranite ridges in the Backwater region.

Threats: As this community occurs on rocky low nutrient terrain it is not threatened, although there is some clearing of this non-agricultural land by hobby farmers.

Threat status: Guyra: LC(ii); **NSW:** LC(i)

Reservation code: Guyra P; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** 126 ha

Conservation status: Poorly represented in reserves but it is sampled in Warra National Park.

Key sites for conservation: Most remaining areas are in good condition. A number of rare species occur in this community. If the eastern part of 'Wattleridge' and portion 14 Parish Hall were protected in a reserve, this community would be classed as well conserved.

Community 13: Silver-top Stringybark (*Eucalyptus laevopinea*)-Forest Ribbon Gum (*Eucalyptus nobilis*) Open Forest on Sediments

Equivalent in Hager and Benson (1994): EF479d; **Forest Type:** 167

Sample sites (4)**:** 100, 101, 262, 273

Landform, substrate and soils: Ridges and slopes on fine-grained sedimentary substrate with light brown, clay soil.

Distribution: Restricted to Avondale State Forest and nearby areas in the south-east of the study area at elevations 1180–1250 m.

Extant area: native understorey: 923 ha; exotic understorey: 0 ha; **Total:** 923 ha

Estimated remaining extent of pre-European extent: 30%

Structure: Open to closed forest, trees 20 m with a dense (50–80%) crown cover probably due to dense regrowth after logging or thinning. Shrub layer absent or very sparse. Ground cover very sparse.

No. native species: 22; **Mean no. per site**: 15 +/- 3

No. exotic species: 2; **Mean no. per site:** 1.5 +/- 0.7

Common native species:

- Trees: *Eucalyptus laevopinea*, *Eucalyptus nobilis*, *Eucalyptus radiata* subsp. *sejuncta*
- Shrubs: *Melichrus urceolatus*, *Lissanthe strigosa*, *Indigofera australis*
- Ground cover: *Poa sieberiana*, *Lomandra multiflora* subsp. *multiflora*, *Hardenbergia violacea*

Indicator native species: *Eucalyptus nobilis*, *Indigofera australis*, *Brachyscome microcarpa*

Common exotic species: *Hypochaeris radicata*

Variability: Uniform, some variation in understorey.

Condition: Much of the forest is regrowth after logging. Grazing may have reduced the biomass in the understorey.

Threats: Much of this stringybark forest has been cleared, although remnants remain in and around Avondale State Forest. Logging and clearing remain the main threats.

Threat status: Guyra: V(i); **NSW:** NT(i)

Reservation code: Guyra: VP; **NSW:** P

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved. Located in Avondale State Forest which could be reserved.

Key sites for conservation: Avondale State Forest

Community 14: Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*)-Forest Ribbon Gum (*Eucalyptus nobilis*)-*Hovea* sp. A Open-Closed Forest (Fig. 23)

Equivalent in Hager and Benson (1994): nil; **Forest Type:** 111

Sample site (3)**:** 163, 164, 275

Landform, substrate and soils: Ridgelines on granite substrate with shallow sandy-loam soil.

Distribution: Naturally restricted community occurring on Mount Nobbler near Backwater in the north-western section of the study area at elevations 1330–1390 m.

Extant area: native understorey: 512 ha; exotic understorey: 0 ha; **Total:** 512 ha

Estimated remaining extent of pre-European extent: 90%

Structure: Open to closed forest (50–80%) crown cover, trees 14 m high, dense shrub cover, sparse ground cover.

No. native species: 45; **Mean no. per site:** 27 +/- 4

No. exotic species: 1; **Mean no. per site:** -

Common native species:

- Trees: *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus nobilis*
- Shrubs: *Hovea* sp. A, *Lomatia silaifolia*, *Leucopogon lanceolatus*, *Platysace ericoides*, *Monotoca scoparia*

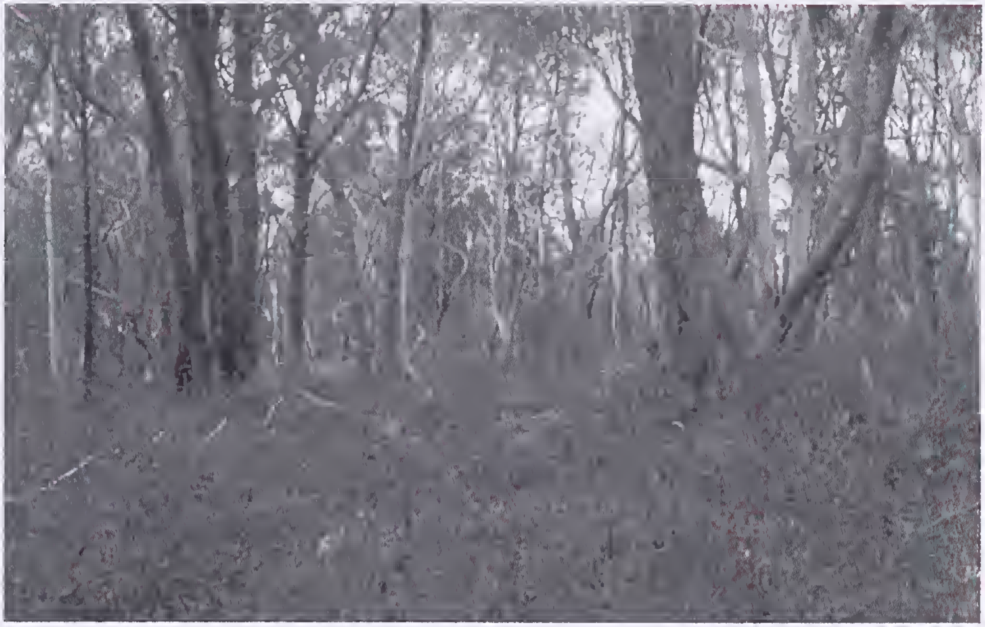

Fig. 23. Community 14, *Eucalyptus radiata* subsp. *sejuncta*-*Eucalyptus nobilis* with a dense understorey dominated by *Hovea* sp A, is restricted to ridges near Mount Nobbler, 3 km northwest of Backwater.

- Ground cover: *Poa sieberiana*, *Poranthera microphylla*, *Lomandra longifolia*, *Hardenbergia violacea*

Indicator native species: *Hovea* sp. A, *Olearia oppositifolia*, *Platysace ericoides*

Common exotic species: None.

Variability: Density of the understorey varies, perhaps due to fire history.

Condition: Very good. Only one weed recorded and not subject to clearing due to the terrain.

Threats: Not threatened as it occurs on steep, rocky ridges. Subject to grazing and some logging.

Threat status: Guyra: LC(iii); **NSW:** LC (iii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved.

Key sites for conservation: Area including sites 163 and 164 on Mount Nobbler.

Community 15: Forest Ribbon Gum (*Eucalyptus nobilis*) -Broad-leaved Stringybark (*Eucalyptus caliginosa*) Open Forest on Leucogranite (Fig. 24)

Equivalent in Hager and Benson (1994): EF414b; **Forest Type:** 160

Sample sites (10): 34, 35, 38, 40, 118, 126, 128, 131, 245, 255

Landform, substrate and soils: Flats and lower slopes on leucogranite substrate with deep, low nutrient, sandy-loam soils.

Distribution: Leucogranite outcrop north of Backwater, particularly near Mount Mitchell in the north-eastern section of the study area, at elevations 1090–1270 m.

Extant area: native understorey: 811 ha; exotic understorey: 0 ha; **Total:** 811 ha

Estimated remaining extent of pre-European extent: 60%

Structure: Open forest to tall open forest, trees 15–25 m high, mid-dense to dense (30–80%) cover. Sparse small tree layer usually present. Shrub layer mid-dense with a sparse ground cover.

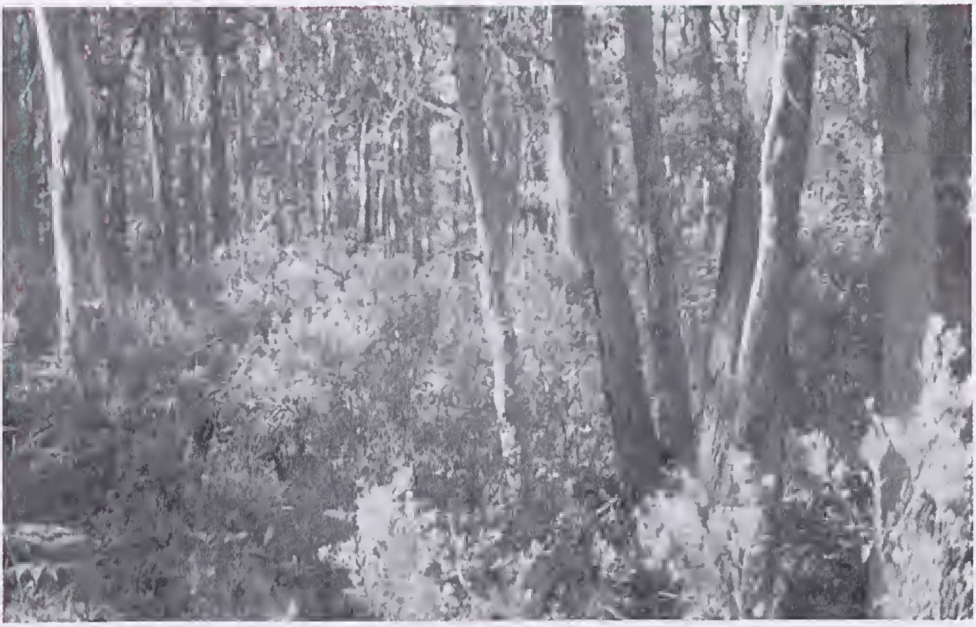

Fig. 24. Community 15, *Eucalyptus radiata* subsp. *sejuncta-Eucalyptus nobilis* open forest with an understorey dominated by *Monotoca scoparia* at site 34, 2 km east of Mount Mitchell.

No. native species: 146; **Mean no. per site:** 46 +/-8

No. exotic species: 4; **Mean no. per site:** 1.5 +/-1

Common native species:

- Trees: *Eucalyptus caliginosa*, *Eucalyptus nobilis*, *Eucalyptus radiata* subsp. *sejuncta*, *Banksia integrifolia* subsp. A
- Shrubs: *Leucopogon lanceolatus*, *Senecio* sp. E, *Rubus parvifolius*, *Acacia filicifolia*, *Persoonia cornifolia*, *Monotoca scoparia*
- Ground cover: *Poa sieberiana*, *Poranthera microphylla*, *Pteridium esculentum*, *Glycine clandestina*, *Geranium solanderi* var. *solanderi*, *Viola betonicifolia*, *Lomandra longifolia*, *Imperata cylindrica*, *Gonocarpus tetragynus*

Indicator native species: *Lomandra filiformis* subsp. *filiformis*, *Acacia filicifolia*, *Viola hederacea*, *Brachyscome nova-anglica*

Common exotic species: *Hypochaeris radicata*

Variability: Understorey varies depending on aspect and recovery period from last fire.

Condition: Good. Little disturbed because it occurs on poor soils.

Threats: Subdivision of land and subsequent development is the main threat to this plant community.

Threat status: Guyra: NT(ii); **NSW:** NT(ii)

Reservation code: Guyra: P; **NSW:** P

No. reserves in study area containing this community: 1; **Area reserved:** 115 ha

Conservation status: A small area is reserved in Warra National Park.

Key sites for conservation: Areas near Mount Mitchell and Portion 14, Parish of Hall are key locations for conserving this community, including sites 126, 128, 131, 255.

Community 16: Broad-leaved Stringybark (*Eucalyptus caliginosa*)-Forest Ribbon Gum (*Eucalyptus nobilis*)-Blakely's Red Gum (*Eucalyptus blakelyi*) Open Forest, Oban River (Fig. 25)

Equivalent in Hager and Benson (1994): EF413c; **Forest Type:** 160

Sample sites (5): 139, 142, 144, 145, 267

Landform, substrate and soils: Slopes and ridges on granite substrate with sandy-loam soils.

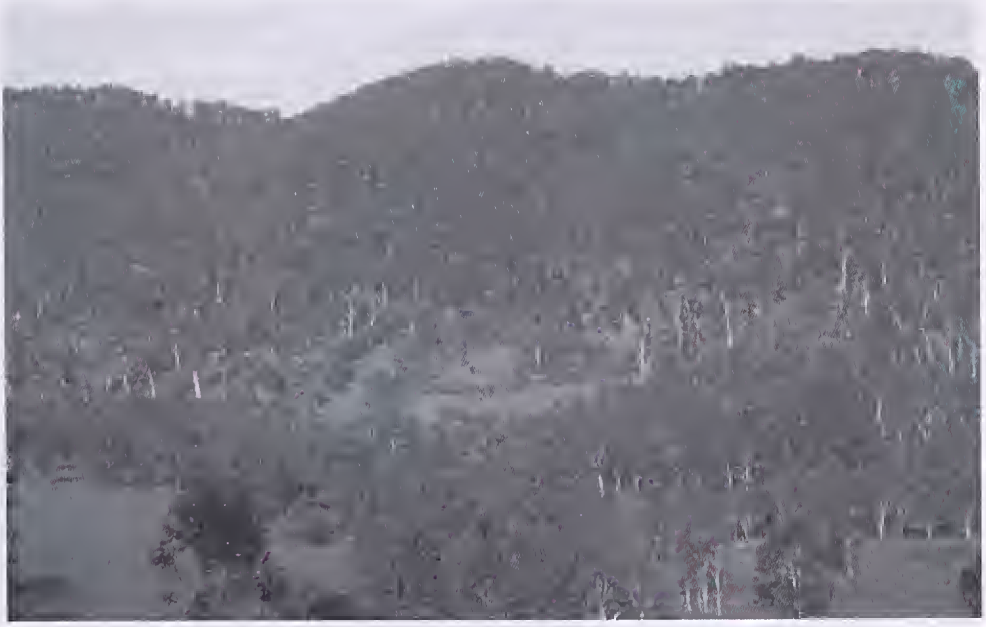

Fig. 25. Community 16, *Eucalyptus nobilis-Eucalyptus caliginosa* open forest on ridges and slopes above the Oban River, 8 km east of Backwater.

Distribution: Oban River and Wards Mistake in the north-eastern section of the study area at elevations 1050–1270 m.

Extant area: native understorey: 824 ha; exotic understorey: 1 ha; **Total:** 825 ha

Estimated remaining extent of pre-European extent: 50%

Structure: Open forest, trees 15–20m high with mid-dense (30–50%) crown cover. Shrubs absent or very sparse, ground cover dense and dominated by grasses.

No. native species: 84; **Mean no. per site:** 36 +/- 6

No. exotic species: 4; **Mean no. per site:** 2 +/- 0.7

Common native species:

- Trees: *Eucalyptus caliginosa*, *Eucalyptus nobilis*, *Eucalyptus blakelyi*
- Shrubs: *Rubus parvifolius*, *Opercularia hispida*
- Ground cover: *Pteridium esculentum*, *Lomandra longifolia*, *Imperata cylindrica*, *Dichelachne micrantha*, *Cymbopogon refractus*, *Poa sieberiana*, *Glycine clandestina*

Indicator native species: *Cheilanthes distans*, *Plectranthus parviflorus*, *Cymbopogon refractus*, *Brachyscome tenuiscapa* var. *pubescens*

Common exotic species: *Hypochaeris radicata*

Variability: *Eucalyptus blakelyi* is present on the lower slopes. The understorey is consistently dominated by grasses.

Condition: Average. Extensive areas cleared on lower slopes and in valleys. Remnants grazed.

Threats: Clearing, grazing, logging and too-frequent fire threaten this community.

Threat status: Guyra: V(ii); **NSW:** V(ii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Not reserved, mostly found on private land.

Key sites for conservation: Sites 139 and 142 on ridge on the eastern side of Oban River, and sites 144 and 145 on the ridge on the western side of the Oban River.

Community 17: Messmate (*Eucalyptus obliqua*)-Forest Ribbon Gum (*Eucalyptus nobilis*) Tall Open Forest (Fig. 26)

Equivalent in Hager and Benson (1994): EF475c; **Forest Type:** 152

Sample sites (35): 16, 27, 42, 52, 56, 61, 107, 117, 130, 134, 135, 136, 137, 138, 150, 151, 152, 153, 154, 162, 165, 168, 169, 170, 173, 174, 210, 211, 212, 247, 257, 263, 266, 279, 280

Landform, substrate and soils: Mainly on protected eastern or southern slopes, occasionally extending onto ridges. Occurring most frequently on granite and leucogranite substrates but also acid volcanics with most often a sandy-loam soil.

Distribution: Mainly east of the Great Dividing Range where rainfall is higher than western areas. Occurs in Mount Duval Nature Reserve, on Little Duval and with a small stand in Boorolong Nature Reserve in the south-western section of the study area. Most common on Days Ridge and Mount Duncan in the north-eastern section of the study area. Also present on leucogranite at Mount Nobbler, Crown Mountain and 'Wattleridge'. Generally at elevations above 1300 m but its occurrences range from 1040–1400 m.

Extant area: native understorey: 2888 ha; exotic understorey: 5 ha; **Total:** 2893 ha

Estimated remaining extent of pre-European extent: 80%

Structure: Tall open forest, trees usually > 25 m high (up to 40 m at site 56 at 'Wattleridge'), crown cover dense (50–80%). Sparse small tree layer often present. Shrubs very sparse, ground cover mid-dense.

No. native species: 189; **Mean no. per site:** 31 +/- 9

No. exotic species: 29; **Mean no. per site:** 4 +/- 3

Common native species:

- Trees: *Eucalyptus obliqua*, *Eucalyptus nobilis*, *Eucalyptus radiata* subsp. *sejuncta*, *Banksia integrifolia* subsp. A
- Shrubs: *Rubus parvifolius*, *Leucopogon lanceolatus*, *Senecio* sp. E, *Lomatia silaifolia*
- Ground cover: *Acaena novae-zelandiae*, *Pteridium esculentum*, *Poa sieberiana*, *Geranium solanderi* var. *solanderi*, *Dichondra repens*, *Desmodium varians*, *Smilax australis*, *Wahlenbergia stricta*, *Galium ciliare*, *Hydrocotyle laxiflora*

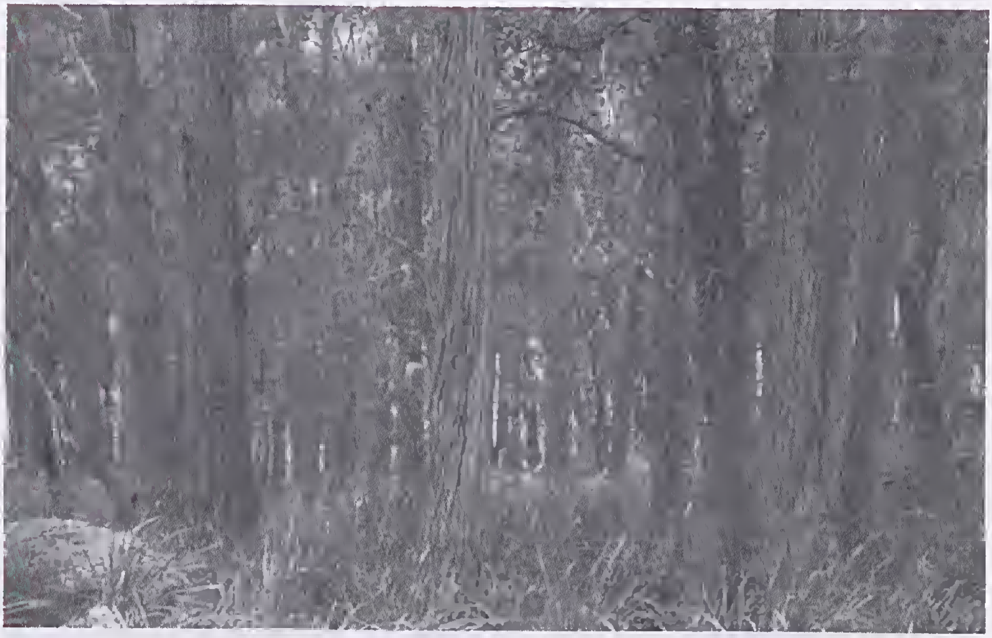

Fig. 26. Community 17, *Eucalyptus obliqua-Eucalyptus nobilis* tall open forest occurs on protected aspects of a number of mountain ranges that receive higher rainfall than surrounding valleys. The understorey varies from mesic to dry, the latter shown here at site 135 on 'Mount View' Days Ridge, where *Lomandra longifolia* dominates.

Indicator native species: *Eucalyptus nobilis, Hydrocotyle geraniifolia, Asplenium flabellifolium*

Common exotic species: *Hypochaeris radicata, Cirsium vulgare, Trifolium repens*

Variability: This group could be divided into three subgroups based on the UPGMA analysis: 1. Sites on Mount Nobbler, Mount Duncan and Days Ridge which are high and wet and contain moist understorey species; 2. Those on the acid volcanics on and near Little Duval which contain a drier understorey; 3. Occurrences on the leucogranite north east of Backwater which contain a number of different understorey species normally found on poorer soils.

Condition: Generally good as this community occurs on high, steep hillsides that have not been totally cleared. Large remnants remain. Some areas have been heavily logged and grazed.

Threats: Isolated clearing continues (for example on the southern side of Mount Nobbler). Heavy logging is threatening the structure of the community in some places, such as Days Ridge. Grazing is less of a threat.

Threat status: Guyra: LC(i); **NSW:** LC(i)

Reservation code: Guyra: M; **NSW**: AC

No. reserves in study area containing this community: 3; **Area reserved:** 179 ha

Conservation status: Moderately well conserved. Represented in Warra National Park, Mount Duval Nature Reserve and Boorolong Nature Reserve.

Key sites for conservation: Other then the present reserves, areas suitable for protection include Little Duval, sections of Days Ridge and Mount Duncan, Mount Nobbler (site 162) and sections of 'Wattleridge'.

Community 18: Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*)-Wattle-leaved Peppermint (*Eucalyptus acaciiformis*) Open Forest on Granite (Fig. 27)

Equivalent in Hager and Benson (1994): EF515b; **Forest Type:** 111

Sample sites (20)**:** 18, 21, 48, 97, 121, 122, 123, 124, 125, 146, 147, 148, 149, 192, 193, 214, 268, 270, 272, 274

Landform, substrate and soils: Exposed plateaux, ridges and slopes mainly on granite substrates with sandy clay soils.

Distribution: Mainly restricted to the north-eastern section of the study area along Wards Mistake Road,

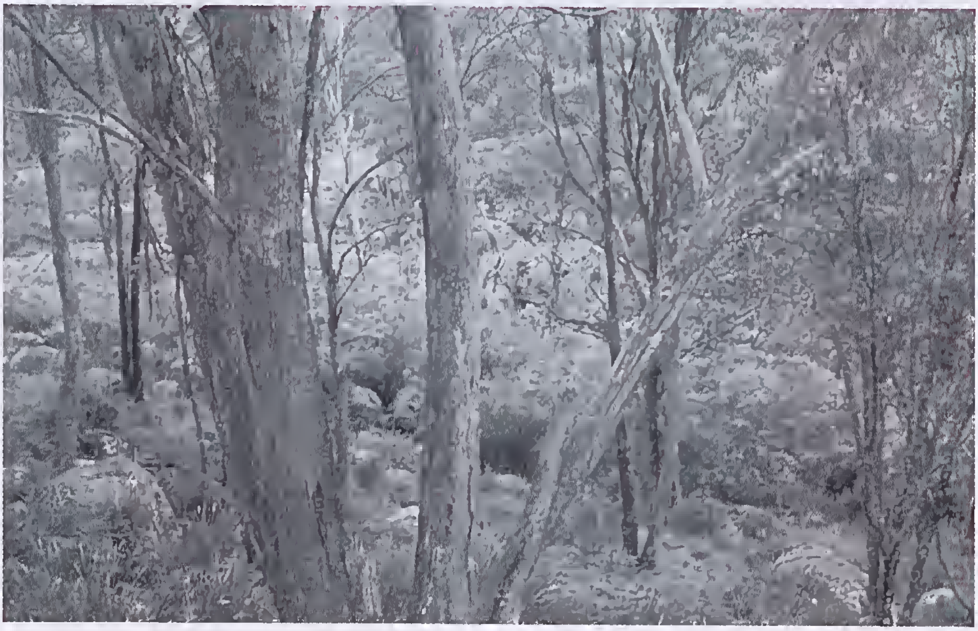

Fig. 27. Community 18 is often dominated by *Eucalyptus radiata* subsp. *sejuncta* with a stratum of small trees of *Banksia integrifolia* subsp. A. This shows site 274 north of the Sara River north west of Backwater on granite substrate.

between Backwater and Llangothlin Lagoon, Aberfoyle Road, Days Ridge and near Backwater, at elevations 1090–1400 m.

Extant area: native understorey: 6753 ha; exotic understorey: 308 ha; **Total:** 7061 ha

Estimated remaining extent of pre-European extent: 40%

Structure: Open forest, trees 15 m high, mid-dense to dense (30–80%) crown cover with a very sparse shrub layer and mid-dense to dense ground cover.

No. native species: 173; **Mean no. per site:** 33 +/- 10

No. exotic species: 26; **Mean no. per site:** 5 +/- 3

Common native species:

- Trees: *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus acaciiformis*, occasionally *Eucalyptus pauciflora*, *Banksia integrifolia* subsp. A
- Shrubs: *Rubus parvifolius*, *Senecio* sp. E
- Ground cover: *Poa sieberiana*, *Dichondra repens*, *Pteridium esculentum*, *Glycine clandestina*, *Geranium solanderi* var. *solanderi*, *Desmodium varians*, *Acaena novae-zelandiae*

Indicator native species: *Eucalyptus acaciiformis*

Common exotic species: *Hypochaeris radicata*, *Trifolium repens*, *Rubus ulmifolius*

Variability: Trees such as *Eucalyptus caliginosa and Eucalyptus dalrympleana* subsp. *heptantha* occur at some sites.

Condition: Varies from good to poor depending on the degree of clearing and grazing. Some roadside remnants are in excellent condition. Some remnants are heavily grazed, thinned and affected by dieback.

Threats: As this community mainly occurs on private land, further clearing and heavy grazing threaten some areas. Dieback affects isolated small patches of forest.

Threat status: Guyra: V(i); **NSW:** V(i)

Reservation code: Guyra: VP; **NSW:** P

No. reserves in study area containing this community: 0; **Area reserved :** 0

Conservation status: Not reserved.

Key sites for conservation: Sites 21 and 122 on road reserve along Wards Mistake Road; site 273 on 'Stonebrook', site 268 at Beesnest Hill on 'Sunnyside' (contains a good patch of the rare *Thesium australe*); Day Trig area.

Community 19: Wattle-leaved Peppermint (*Eucalyptus acaciiformis*)-Broad-leaved Stringybark (*Eucalyptus caliginosa*)-Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*) Open Forest on Sediments (Fig. 28)

Equivalent in Hager and Benson (1994): EF515b,e; Forest Type: 111
Sample site (3): 24, 95, 183

Landform, substrate and soils: Undulating terrain composed of fine grain sedimentary rocks and clayey soils.

Distribution: Rockvale Road and Macleay Range, north-east of Armidale, at 1200 m elevation.

Extant area: native understorey: 489 ha; exotic understorey: 20 ha; **Total:** 509 ha

Estimated remaining extent of pre-European extent: 20%

Structure: Open-forest with trees 8–14m high with a 35–50% crown cover, shrubs sparse, dense ground cover dominated by grasses and forbs.

No. of native species: 63; **Mean no. per site:** 40 +/- 2

No. exotic species: 13; **Mean no. per site:** 6 +/- 2

Common native species:

- Trees: *Eucalyptus acaciiformis*, *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus caliginosa*
- Shrubs: *Allocasuarina littoralis*, *Acacia filicifolia*, *Ozothamnus diosmifolia*
- Ground cover: *Poa sieberiana*, *Themeda australis*, *Chrysocephalum apiculatum*

Indicator native species: NA

Common exotic species: *Hypochaeris radicata*, *Trifolium* species

Variability: Analysis revealed that this community shares many species with community 2 which also occurs on sediments in the area. Much of the forest is regrowth in variable sized patches.

Condition: Poor. Mostly cleared for agriculture and most remnants are grazed. Remnants along roadsides have better developed understoreys.

Threats: Further clearing, grazing of understorey, road-widening.

Threat status: Guyra: E(ii); **NSW:** E(ii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

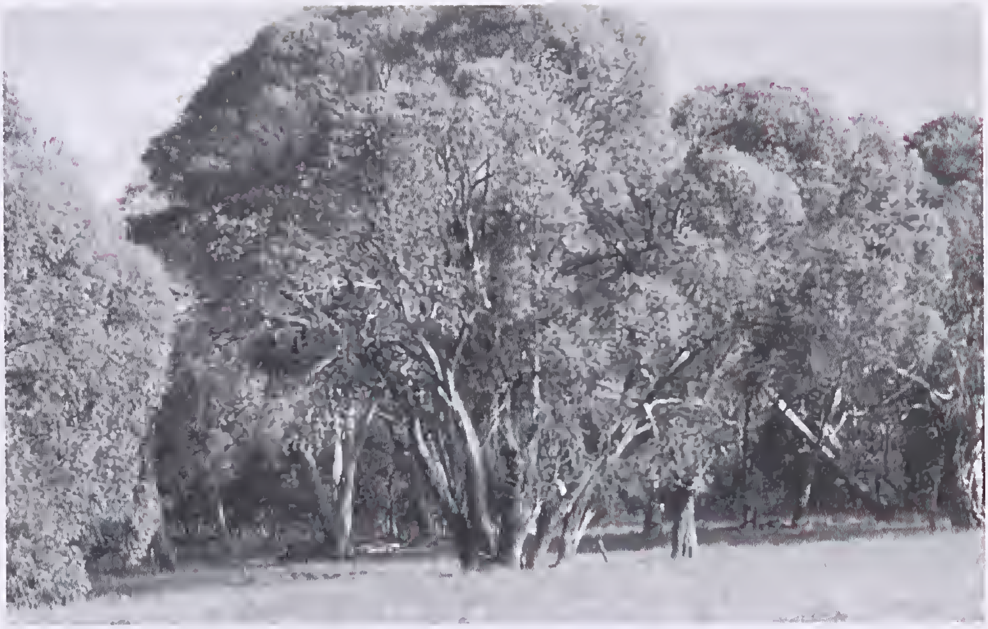

Fig. 28. Community 19, *Eucalyptus acaciiformis* low open forest on sedimentary substrate near Rockvale Road east of Armidale. Only small remnants of this community remain. Floristically it has affinity to Community 2 — Broad-leaved Stringybark (*Eucalyptus caliginosa)* open forest on sediments.

Conservation status: Not reserved.

Key sites for conservation: Roadside remnants along Rockvale Road and Ebor Road. There may be better sites outside the study area.

Community 20: Heath Swamps on Leucogranite and Granite (Fig. 29)

Equivalent in Hager and Benson (1994): NA; Forest Type: 223

Sample site (5): 4, 36, 51, 167, 171

Landform, substrate and soils: Valley swamps on leucogranite and granite acid-organic soils.

Distribution: North-east of Backwater and at Mount Duncan, at elevations 1200–1390 m.

Extant area: native understorey: 369 ha; exotic understorey: 0 ha; **Total:** 369 ha

Estimated remaining extent of pre-European extent: 80%

Structure: Open-closed shrubland/sedgeland, shrubs 1–2 m with 50–100% crown cover, with a dense sedgeland ground cover often growing in *Sphagnum* moss.

No. of native species: 92; **Mean no. per site:** 30 +/- 6

No. exotic species: 9; **Mean no. per site:** 20 +/- 4

Common native species:

- Trees: Generally absent, occasionally *Eucalyptus acaciiformis* present on margins.
- Shrubs: *Leptospermum gregarium*, *Baeckea gunniana*, *Lomatia fraseri*, *Hakea microcarpa*, *Epacris microphylla*, *Epacris breviflora*, *Banksia cunninghamii* subsp. A, *Callistemon pityoides*
- Ground cover: *Baloskion stenocoleus*, *Sphagnum cristatum* (a moss), *Lepyrodia anarthria*, *Gonocarpus micranthus*, *Schoenus apogon*, *Xanthorrhoea glauca* subsp. *glauca*

Indicator native species: *Baloskion stenocoleus*, *Sphagnum cristatum*, *Lepyrodia anarthria*, *Gonocarpus micranthus*, *Leptospermum gregarium*, *Callistemon pityoides*, *Hakea microcarpa*, *Baeckea gunniana*, *Epacris microphylla*, *Lomatia fraseri*

Common exotic species: None.

Variability: The density of the shrub layer varies between swamps due to hydrological differences or fire history, however the floristic assemblages are consistent.

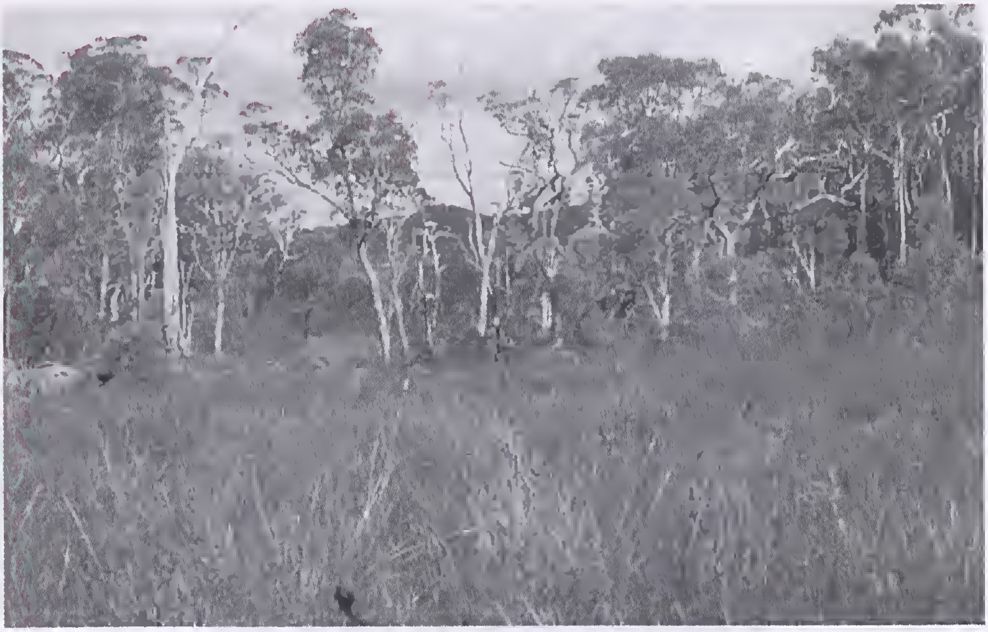

Fig. 29. Community 20, heath swamp dominated by shrubs and sedges. These swamps occur on leucogranite near Backwater such as site 51 shown here in Kangaroo Gully.

Condition: Very good. Little disturbed by agriculture and not subject to heavy grazing.

Threats: Hobby farming activities in the Mount Mitchell and Sara River areas with some clearing, drainage and roadworks.

Threat status: Guyra: LC(ii); **NSW**: LC(ii)

Reservation code: Guyra: P; **NSW:** M

No. reserves in study area containing this community: 1; **area reserved:** 15 ha

Conservation status: Similar swamps are located in reserves outside the study area in the NET Bioregion, for example Bald Rock and Gibraltar Range National Parks. However, these swamps are poorly reserved in the study area with limited representation in Warra National Park.

Key sites for conservation: The reservation of the many swamps in portion 14, Parish Hall and on 'Wattleridge' would greatly improve the conservation status of this community.

Community 21: Mallee (*Eucalyptus codonocarpa*) and Heath on rocky outcrops on Leucogranite (Fig. 30)

Equivalent in Hager and Benson (1994): MA209a; **Forest Type:** 223, 225

Sample sites(6): 5, 53, 59, 119, 166, 172

Landform, substrate and soils: Rocky ridges on leucogranite with skeletal, sandy soil.

Distribution: Restricted to the leucogranite outcrop north-east of Backwater including ridges near Paddys Gully, Mount Nobbler and Crown Mountain at elevations 1020–1400 m.

Extant area: native understorey: 241 ha; exotic understorey: 0 ha; **Total:** 241 ha

Estimated remaining extent of pre-European extent: 95%

Structure: Sparse (10–30%) crown cover of mallee or woodland, with mid-dense shrub layer interspersed with areas of bare rock, sparse ground cover.

No. native species: 98; **Mean no. per site:** 29 +/- 6

No. exotic species: 1; **Mean no. per site:** -

Common native species:

- Trees: *Eucalyptus codonocarpa*, *Eucalyptus caliginosa*
- Shrubs: *Leptospermum novae-angliae*, *Platysace lanceolata*, *Mirbelia confertiflora*, *Leucopogon neo-anglicus*, *Kunzea obovata*, *Hovea beckeri*, *Hibbertia linearis*, *Dillwynia phylicoides*, *Brachyloma saxicola*, *Acacia falciformis*, *Allocasuarina littoralis*

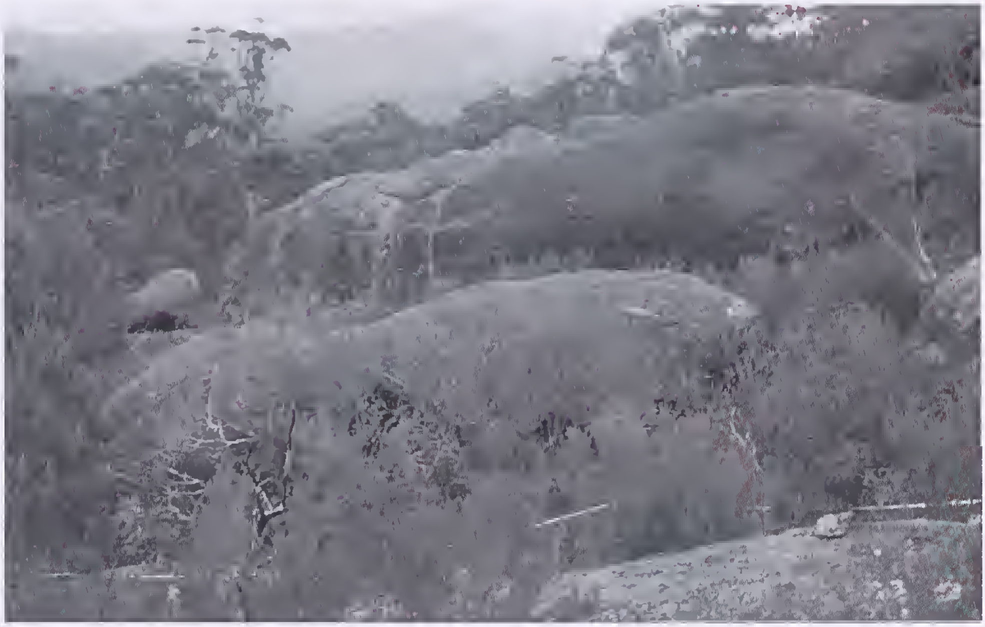

Fig. 30. Community 21, mallee and heath growing among leucogranite rocky outcrops at site 5 on the property Wattleridge north of Backwater.

- Ground cover: *Entolasia stricta*, *Lomandra longifolia*, *Lepidosperma gunnii*, *Patersonia glabrata*

Indicator native species: *Eucalyptus codonocarpa*, *Leucopogon neo-anglicus*, *Platysace lanceolata*, *Lepidosperma gunnii*, *Kunzea obovata*, *Hovea beckeri*, *Leptospermum novae-angliae*, *Acacia falciformis*, *Dillwynia phylicoides*, *Entolasia stricta*

Common exotic species: None.

Variability: Grades into community 11 along ridges. Some sites contain the mallee eucalypt *Eucalyptus codonocarpa*, others do not.

Condition: Very good. Due to its location on rocky ridges it has not been cleared or heavily grazed.

Threats: Hobby farm subdivision that could lead to increased disturbance and grazing by stock including goats.

Threat status: Guyra: LC(iii); **NSW:** LC(iii)

Reservation code: Guyra: P; **NSW:** AC

No. reserves in study area containing this community: 1; **Area reserved:** 4 ha

Conservation status: Sampled in Warra National Park and in other reserves north of the study area. If portion 14, Parish Hall and 'Wattleridge' were reserved this community would be well conserved.

Key sites for conservation: Sites on 'Wattleridge' and the adjoining portion 14, Parish of Hall.

Community 22: Narrow-leaved Peppermint (*Eucalyptus radiata* subsp. *sejuncta*)-Broad-leaved Stringybark (*Eucalyptus caliginosa*) Open Forest with dense shrubland on Leucogranite (Fig. 31)

Equivalent in Hager and Benson (1994): EF515e; **Forest Type:** 111

Sample sites (2): 50, 132

Landform, substrate and soils: Flats on leucogranite with low nutrient, coarse, sandy soil.

Distribution: Restricted to between Paddys Gully Road and Sara River north-east of Backwater at an elevation of 1220 m.

Extant area: native understorey: 316 ha; exotic understorey: 0 ha; **Total:** 316 ha

Estimated remaining extent of pre-European extent: 95%

Structure: Open forest, trees 12 m high, mid-dense (30–50%) crown cover, with a closed (80%) cover of a tall shrub layer and a very sparse ground cover.

No. native species: 35

No. exotic species: None.

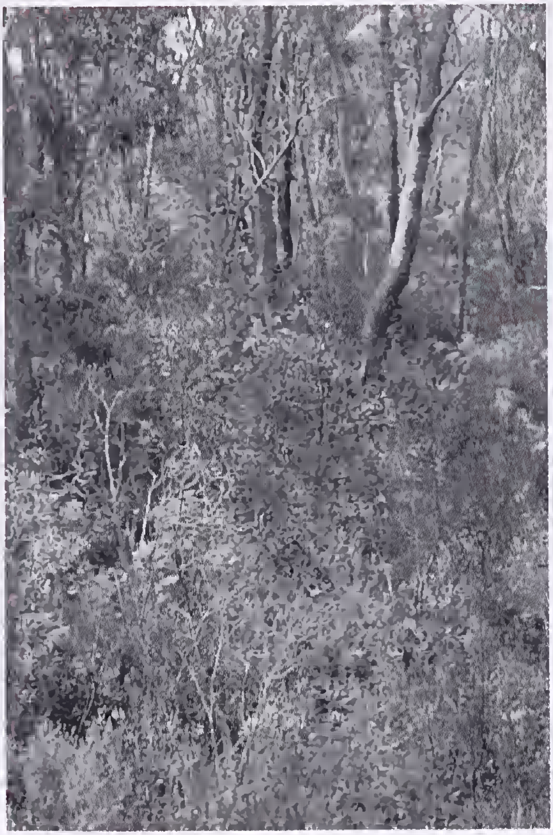

Fig. 31. Community 22 is composed of low open forest of *Eucalyptus radiata* subsp. *sejuncta* and *Eucalyptus caliginosa* with a dense shrub understorey. It is restricted to flats on leucogranite near Kangaroo Gully northeast of Backwater.

Common native species:

- Trees: *Eucalyptus radiata* subsp. *sejuncta*, *Eucalyptus caliginosa*
- Shrubs: *Leptospermum brevipes*, *Leptospermum novae-angliae*, *Mirbelia confertiflora*, *Rhytidosporum procumbens*, *Platysace ericoides*, *Petrophile canescens*, *Hibbertia riparia*, *Acacia buxifolia* subsp. *buxifolia*, *Persoonia cornifolia*, *Cryptandra scortechinii*, *Grevillea scortechinii* subsp. *sarmentosa*
- Ground cover: *Patersonia glabrata*, *Lepidosperma laterale*, *Entolasia stricta*, *Goodenia hederacea* subsp. *hederacea*

Indicator native species: (Only two sites, so illustrative only) *Cryptandra scortechinii*, *Petrophile canescens*, *Hibbertia riparia*, *Acacia buxifolia*, *Rhytidosporum procumbens*, *Hibbertia riparia*, *Choretrum pauciflorum*, *Patersonia glabrata*, *Lepidosperma laterale*

Common exotic species: None.

Variability: Consistent floristics.

Condition: Very good. No weeds and not heavily grazed.

Threats: Too-frequent fire (< 10 year intervals) and bulldozing of fire trails and any future subdivision of portion 14, Parish of Hall are the main threats to this community. While little of this plant community has yet been cleared it is threatened by hobby farming clearing.

Threat status: Guyra: LC(iii); **NSW:** LC(iii)

Reservation code: Guyra: VP; **NSW:** VP

No. reserves in study area containing this community: 0; **Area reserved:** 0

Conservation status: Rare plant community that is not reserved.

Key sites for conservation: Portion 14, Parish of Hall.

Community 23: New England Riparian Shrubland (Fig. 32) (not mapped due to the linear shape of this community)

Equivalent in Hager and Benson (1994): NA; **Forest Type:** NA

Sample sites (15)**:** 32, 39, 43, 49, 98, 127, 141, 218, 232, 241, 252, 271, 276, 281, 296

Landform, substrate and soils: Between or on the banks of watercourses on a range of substrates, growing on alluvial sand-loam or skeletal soils.

Extant area: NA because not mapped

Estimated remaining extent of pre-European extent: 30%

Distribution: Widespread along creeks and rivers in the study area at elevations 1000–1280 m.

Structure: Open to mid-dense tall shrubland often with overhanging trees, with a sparse to mid-dense ground cover.

No. native species: 215; **Mean no. per site:** 36 +/- 12

No. exotic species: 52; **Mean no. per site:** 10 +/- 8

Common native species:

- Trees: *Eucalyptus nova-anglica*, *Eucalyptus pauciflora*
- Shrubs: *Leptospermum polygalifolium* subsp. *transmontanum*, *Rubus parvifolius*, *Hakea microcarpa*
- Ground cover: *Lomandra longifolia*, *Adiantum aethiopicum*, *Epilobium billardierianum* subsp. *cinereum*, *Carex gaudichaudiana*, *Hydrocotyle tripartita*, *Poa labillardieri*, *Myriophyllum variifolium*

Indicator native species: *Leptospermum polygalifolium* subsp. *transmontanum*, *Adiantum aethiopicum*, *Epilobium billardierianum* subsp. *cinereum*, *Carex gaudichaudiana*, *Poa labillardieri*. The threatened *Callitris oblonga* subsp. *parva* occurs along some creeks on leucogranite

Common exotic species: *Hypochaeris radicata*, *Rubus ulmifolius*, *Conyza albida*, *Trifolium repens*, *Centaurium erythraea*, *Holcus lanatus*

Variability: Variation occurs in the structure and floristics depending on the substrate and depth of soil (creek bank compared to rocky river bed). It is a species rich community, as illustrated by 82 species being recorded at site 252 on the Gara River.

Condition: Varies depending on location. Sites on leucogranite on the Sara River are in good condition

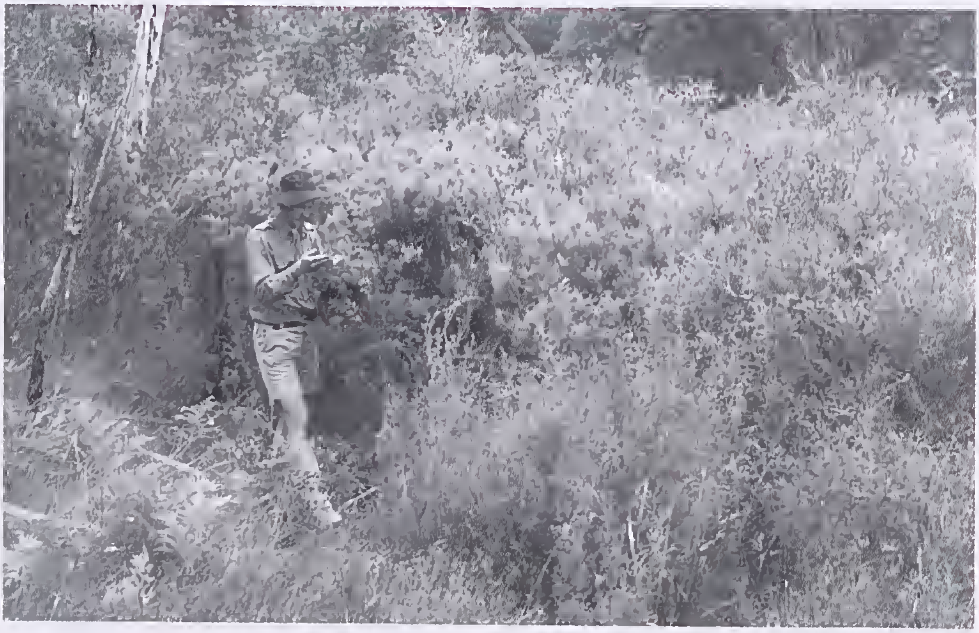

Fig. 32. Community 23, riparian shrubland lines watercourses on various substrates. It is often dominated by *Leptospermum polygalifolium* subsp. *transmontanum*. This shows the vulnerable Pygmy Cypress Pine (*Callitris oblonga* subsp. *parva*) growing in Backwater creek.

containing few exotic species, whereas riverine vegetation in more disturbed landscapes contain a greater number of exotic species and are not buffered by adjoining natural vegetation.

Threats: Weed invasion (including blackberry) and pollution and sedimentation of watercourses due to over-clearing in catchments. Susceptible to river mining.

Threat status: NSW: Guyra: E (ii); **NSW** V(ii)

Reservation code: Guyra: VP; **NSW:** M

No. reserves in study area containing this community: 1; **Area reserved:** NA

Conservation status: Probably moderately well reserved or protected on a state and bioregional perspective, although subject to weed invasion. Protected in Warra National Park and along the Sara River in the study area. Riverine vegetation on higher nutrient soils such as basalt are more threatened and not reserved.

Key sites for conservation: Vegetated river courses in the study area, particularly the Sara, Gara and Aberfoyle Rivers. Site 49 at Stuttering Dick's Creek at Backwater contains a remnant stand of *Callitris oblonga* subsp. *parva*.

Community 24: Basalt Plateau Lagoons (Fig. 33)

Equivalent in Hager and Benson (1994): NA; **Forest Type:** NA

Sample sites (6): 45, 47, 277, 278, 311, 312

Landform, substrate and soils: In closed depressions on an undulating, high, mostly basalt plateau with organic soils forming in the lagoons over deep chocolate loam soils. 18 of the 28 lagoons are small — 5 ha in size. Two are 450 ha. Lunettes are present on the eastern shore of some of the lagoons. The lagoons probably formed during the last ice age through the process of deflation, in a similar way to those on the Monaro tableland on the Southern Tablelands of NSW (Benson & Jacobs 1994).

Distribution: Centred on Guyra, on the higher parts of the basalt plateau from Llangothlin in the north to Armidale in the south, at elevations 1310–1350 m.

Extant area: native understorey: 1090 ha; exotic understorey: 0 ha; **Total:** 1090 ha

Estimated remaining extent of pre-European extent: 30%

Structure: Closed to mid-dense sedgeland and grassland on the shores of open water or extending across shallow or dry lagoons.

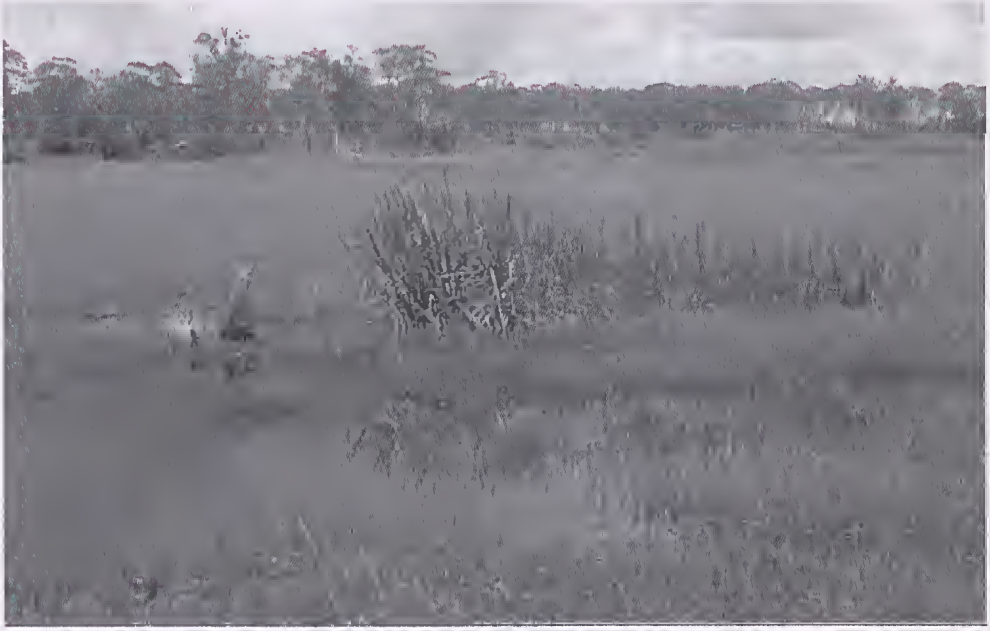

Fig. 33. Community 24, site 311 at Lagoon Farm is one the few basalt plateau lagoons that has not been drained. These lagoons contain a range of water plants including *Myriophyllum variifolium* (foreground) and the grass *Glyceria australis* (background).

No. native species: 33; **Mean no. per site:** 14 +/- 5

No. exotic species: 8; **Mean no. per site:** 2.3 +/- 1.4

Common native species:

- Trees: None.
- Shrubs: None.
- Ground cover: Water plants, sedges, forbs and grasses are present. *Potamogeton tricarinatus, Myriophyllum variifolium, Nymphoides geminata, Eleocharis acuta, Stellaria angustifolia, Pratia surrepens, Hydrocotyle tripartita, Juncus fockei, Epilobium billardierianum* subsp. *cinereum, Brachyscome radicans, Agrostis avenacea, Glyceria australis*

Indicator native species: *Potamogeton tricarinatus, Myriophyllum variifolium, Nymphoides geminata, Eleocharis acuta, Stellaria angustifolia, Pratia surrepens, Juncus fockei, Hydrocotyle tripartita, Brachyscome radicans, Agrostis avenacea, Glyceria australis, Ranunculus inundatus, Utricularia dichotoma*

Common exotic species: *Holcus lanatus, Juncus articulatus*

Variability: Variable, depending on depth of the lagoon and perhaps other factors. The native grass *Glyceria australis* dominated sites 277 and 278 at Mother of Ducks Lagoon and site 311 Lagoon Farm at the time of the survey, but was less common at other lagoons.

Condition: Those lagoons left undrained are in good condition and retain a variety of water plants, but most of the lagoons in the region have been drained or impounded.

Threats: A vulnerable plant community because most of the 28 lagoons that once existed in the study area (D. Bell pers. comm.) have been drained or impounded. Disrupted hydrology remains the main threat to the lagoons not protected in reserves. Grazing, agricultural pollution and uncontrolled recreational use may also threaten the vegetation.

Threat status: Guyra: E(ii); **NSW:** E(ii)

Reservation code: Guyra: P; **NSW:** P

No. reserves in study area containing this community: 2; **Area reserved:** 208 ha

Conservation status: Little Llangothlin and Mother of Ducks Nature Reserves protect sections of two of the lagoons.

Key sites for conservation: All remaining undrained lagoons should be protected and some previously drained ones could be restored. Site 311 at Lagoon Farm near Black Mountain is a key site for protection. This lagoon along with the surrounding Snow Gum woodland should be protected as a nature reserve or under a conservation agreement with the landholder.

Reservation status and sites of botanical significance

Table 4 lists the area and proportion of existing extent (based on 1989 aerial photographs) of each plant community in reserves in the study area. Only 0.72% of the study area is reserved. None of the 24 plant communities are currently adequately conserved, using the definitions of Hager and Benson (1994) or JANIS (1996). This is not surprising given that 74% of the vegetation has been cleared and only five small conservation reserves have been established. The proportion of cleared land is higher than for other parts of the New England Bioregion (Fig. 34), probably because a large part of the study area is composed of basalt-derived soil and undulating topography.

Table 5 lists the most significant locations for conservation. These have been selected based on the criteria of representativeness of a plant community, condition, size, the presence of rare, threatened or other significant species. These locations include publicly owned land including conservation reserves, roadsides and travelling stock reserves as well as private land.

Backwater

The most significant area for conservation is the leucogranite vegetation remnant near Backwater. Most of this is private land, but it includes public land along the Sara River and in Warra National Park. This is the largest intact vegetation remnant in the study area (Fig. 35) and contains the highest number of plant communities and rare plant species. Most of the communities on this leucogranite outcrop are in good condition, although some land clearing was occurring during the time of survey. Further clearing could threaten some of these communities.

The most critical portions of land for conservation in this area are portion 14, Parish of Hall, County of Clarke and the adjoining eastern vegetated part of portion 54, Parish of Coventry, County of Clarke on the property 'Wattleridge'. These areas contain eight of the 24 plant communities defined in this survey (communities 10, 11, 12, 15, 17, 20, 21, 22 and 23). The rare or threatened plant species *Callitris oblonga* subsp. *parva*, *Eucalyptus codonocarpa*, *Grevillea scortechinii* subsp. *sarmentosa*, *Persoonia procumbens*, *Eucalyptus camphora* subsp. *relicta*, *Daviesia elliptica*, *Muehlenbeckia costata*, *Monotaxis macrophylla*, *Thelionema grande*, *Leionema ambiens*, *Acacia brunioides* subsp. *brunioides* and *Pseudanthus divaricatissimus* are present on the leucogranite outcrop north and south of the Sara River.

On the northern side of the Sara River the Warra National Park was declared in 1999. It was previously part of Warra State Forest. The NSW National Parks and Wildlife Service has a national park proposal over the vegetated lands on the southern side of the Sara River including portion 14, Parish of Hall, and the eastern part of the property 'Wattleridge'. This land remains in private ownership but 'Wattleridge' has recently been purchased by the Guyra Aboriginal Land Council. Until this land is managed for conservation, hobby farm subdivision and development may threaten the integrity of the vegetation and compromise Warra National Park.

Table 4: Area, threat and reservation status of the vegetation communities on Guyra 1: 100 000 sheet.

Plant Community	Estimated pre-European extent (ha) (approx.)	Estimated original rarity in NSW	Remaining extent (ha) (% pre-European extent)	Threat Status for study area	Area in reserves (ha) in study areas	% pre-European extent reserved	Reservation status for study area
1. *E. blakelyi-E. melliodora* Open Forest	33 000	Common	6612 (20)	E	1	0.003	VP
2. *E. caliginosa* Open Forest	17 000	Common	11 146 (65)	LC	443	2.4	P
3. *E. laevopinea* Open Forest	20 000	Common	10 084 (50)	NT	373	1.5	P
4. *E. banksii-E. laevopinea* Open Forest	500	Restricted	337 (70)	NT	13	2.7	P
5. *E. youmanii-E. andrewsii-E. nicholii-E. subtilior* Open Forest	22 000	Common	3330 (15)	E	0	0	VP
6. *E. viminalis-E. dalrympleana-E. pauciflora* Open -Tall Open Forest with a Grassy Understorey on basalt	44 500	Common	6643 (15)	E	17	0.04	VP
7. *E. stellulata-E. pauciflora* Low Open Forest or Low Open Woodland with a grassy understorey	18 000	Common	1819 (10)	E	27	0.15	VP
8. *E. nova-anglica* Woodland on basalt	7000	Common	345 (5)	CE	0	0	VP
9. *E. nova-anglica* Woodland on sediments	13 000	Common	1979 (15)	E	54	0.4	VP
10. *E. nova-anglica-E. pauciflora* Open Forest on granite and leucogranite	18 000	Common	4458 (25)	E	2	0.01	VP
11. *E. caliginosa-E. dalrympleana* Open Forest on leucogranite	7300	Common	4397 (60)	NT	56	0.76	VP
12. *E. campanulata* Open Forest on leucogranite	2500	Restricted	2118 (90)	LC	126	5.36	M
13. *E. laevopinea-E. nobilis* Open Forest on sediments	3000	Common	923 (30)	V	0	0	VP

Plant Community	Estimated pre-European extent (ha) (approx.)	Estimated original rarity in NSW	Remaining extent (ha) (% pre-European extent)	Threat Status for study area	Area in reserves (ha) in study areas	% pre-European extent reserved	Reservation status for study area
14. *E. radiata-E. nobilis-Hovea* sp. A Open Closed Forest	600	Rare	512 (90)	LC	0	0	VP
15. *E. nobilis-E. caliginosa* Open Forest on leucogranite	1400	Restricted	811 (60)	NT	115	8	M
16. *E. caliginosa-E. nobilis-E. blakelyi* Open Forest, Oban River	1700	Restricted	825 (50)	V	0	0	VP
17. *E. obliqua-E. nobilis* Tall Open Forest	3600	Common	2893 (80)	LC	179	5	M
18. *E. radiata-E. acaciiformis* Open Forest on granite	17 600	Common	7061 (40)	V	0	0	VP
19. *E. acaciiformis-E. caliginosa-E. radiata* Low Open Forest on sediments	2500	Restricted	509 (20)	E	0	0	VP
20. Heath Swamps on leucogranite and granite	500	Restricted	369 (80)	LC	15	3.26	P
21. *E. codonocarpa* and heath on rocky outcrops on leucogranite	250	Rare	241 (95)	LC	4	1.6	P
22. *E. radiata-E. caliginosa* Open Forest with dense shrubland on leucogranite	330	Rare	316 (95)	LC	0	0	VP
23. New England Riparian Shrubland	NA	Restricted	NA	E	NA	NA	VP
24. Basalt Plateau Lagoons	3000	Restricted	1000 (30)	E	208	7.00	M

Remaining extent is calculated from the GIS, while pre-European extent is estimated. The five conservation reserves in the study area also contain 271 ha of cleared land. Area of basalt lagoons (community 24) is inflated due to size of impoundment of Llanglothlin Lagoon. 'Original Rarity' is used to help define threat status. It refers to an estimation of the pre-European extent of the plant community in Australia: Common > 10 000 ha, Restricted 1 000 to 10 000 ha, and Rare < 1000 ha. The threat categories are based on IUCN (1999): CE = critically endangered, E = endangered, V = vulnerable, NT = near threatened, LC = least concern. Application of the threat codes is based on the proportion of the remaining extent to estimated pre-European extent (see text). Reservation codes are calculated by comparing extent reserved with the estimated pre-European extent in the study area: VP = very poor (< 1%), P = poor (1–5%), M = moderately well conserved (5–10%), AC = adequately conserved (10–25%), EC = exceptionally well conserved (> 25%). Riparian vegetation (community 23) was not mapped but threat and reservation estimates are provided. The extent of pre-European natural grasslands is also not included.

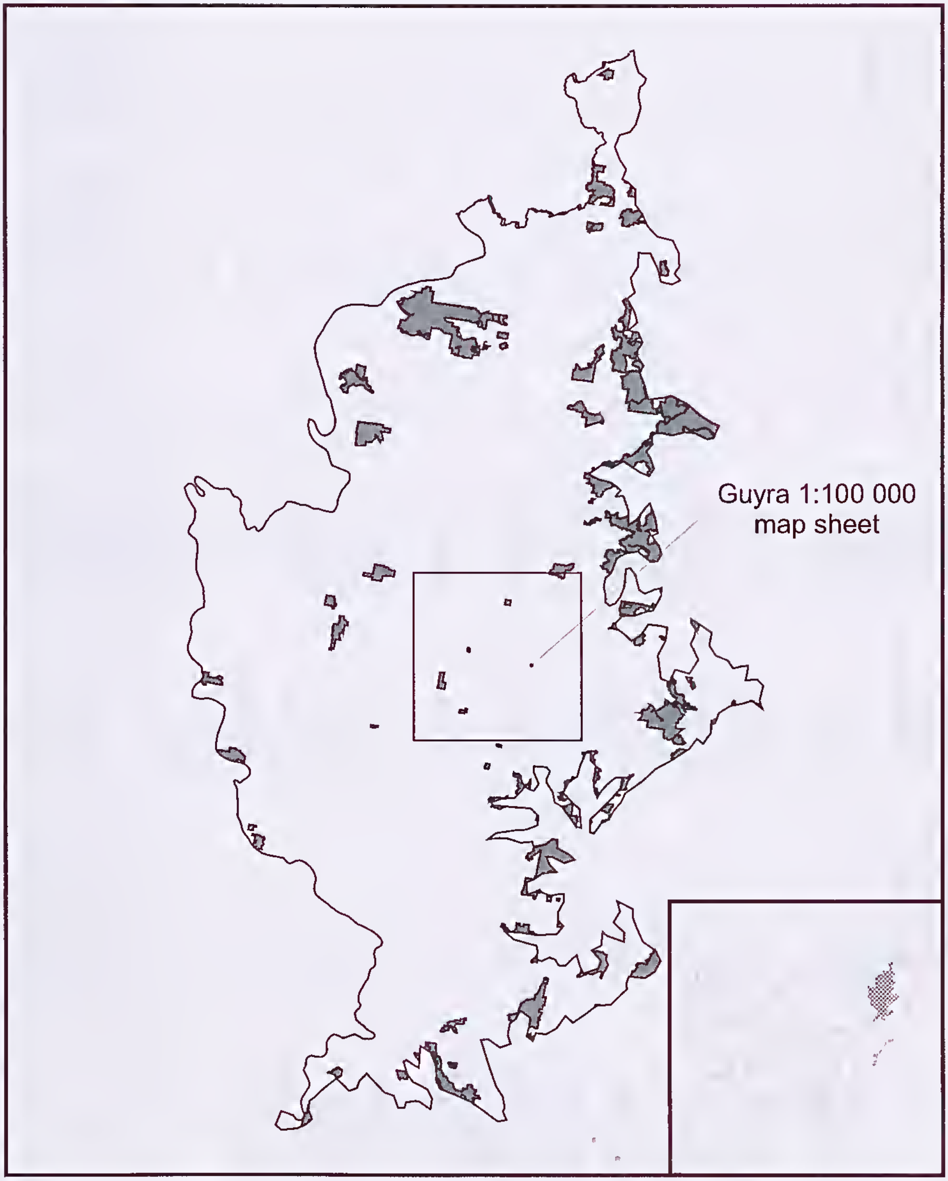

Fig. 34. Distribution of conservation reserves in the New England Tableland Bioregion. Only 0.72% of the study area is reserved compared to 7.5% for the Bioregion as a whole (data from NSW NPWS).

Table 5: Sites of botanical significance in the Guyra 1:100 000 map sheet area.

Justification criteria: T = contains rare or threatened plant species; S = contains plant species of regional significance; C = is in relatively good condition; M = is well fenced or easy to manage in other ways; D = contains high diversity of plant species; R = outstanding example of a plant community.

Locations or sites	Comm.	Location	Justification
Mother of Ducks Lagoon Nature Reserve	24	Mother of Ducks Lagoon, Guyra	T C M R
Little Llangothlin Nature Reserve	24, 6	Little Llangothlin Lagoon, Guyra	T C M R RAMSAR site
Boorolong Nature Reserve	2,3,4	North-west of Armidale	C M R
Mount Duval Nature Reserve	2,3,17	Mount Duval north of Armidale	C M D R
Warra National Park and Warra State Forest	10, 11, 12, 15, 17, 20, 21, 23	Sara River on leucogranite north of Backwater	T S C M D R
Portion 14 and Wattleridge and Sara River reserve.	10, 11, 12, 15, 17, 20, 21, 23	North of Backwater	T S C M D R
Parts of Days Ridge	2, 17, 18	20 km N/E of Guyra	C D R
Lagoon at 'Lagoon Farm' and adjoining ridge	24, 6	Black Mountain	C M D R
Avondale State Forest	13	Rockvale Rd east of Armidale	C M R
Mount Nobbler: sites 162, 163, 164	14, 17	North of Backwater	S C D R
6, 7	6	TSR New England Hwy Guyra	C R
10	6	Crown Reserve Ben Lomond	C M R
12, 13	5	Wandsworth Rd	T C R
14	5	TSR Tingha Rd	T C R
15, 191	9	Tingha Rd	C R
21	18	Wards Mistake Rd	C M D R
22	10	Wards Mistake Rd	C R
28, 113	1, 3	Thunderbolts Cave TSR	T C M D R
49	23	Stuttering Dicks Ck Backwater	T
67	9	Rockvale Rd	C R
80	4	Sunnyside Rd	S C M R
82	1	P 55 Thalgarrah	C R
84	1	Rockvale Rd TSR	S C M R
92	2	Eastview Rd	C R
93	9	Rockvale Rd Wollomombi River	C R
95	19	Rockvale Rd	C R
143	10	Oban River	C R
155	6	Baldersleigh Rd	T
175	2	Wandsworth Rd	C R
177	5	Happy Valley	T C R
180,181,182	5	Roadside reserves Aberfoyle Rd	T C D R
186, 187	6	New England Hwy TSR Ben Lomond Range	M C R
213	2	Little Duval	C R

Locations or sites	Comm.	Location	Justification
215	5	Wychwood near Fleetwood	T C M D
221	5	Old Armidale Rd	S C D R
223	1	Old Armidale Rd	C R
235	10	Granite Springs Oban River	R C S
268	18	near Beesnest Hill	T R
273	18	Stonebrook	C R
287, 288	5	west of Reedy Creek HS	S C D R
299, 306	4	Abington Ck	C R
309	2	Caer Timvil	C R

Avondale State Forest

Although the state forests in the area are not specifically reserved for conservation, they afford some protection to a number of plant communities (except for Armidale State Forest, which is pine plantation). Avondale State Forest contains stands of community 13 which is otherwise not protected on public land.

Days Ridge

This is located in the central-eastern section of the map sheet and contains remnant forests of *Eucalyptus obliqua-Eucalyptus nobilis* (community 17) and *Eucalyptus radiata* subsp. *sejuncta* (community 18). It is mainly private land and parts of it have been substantially logged.

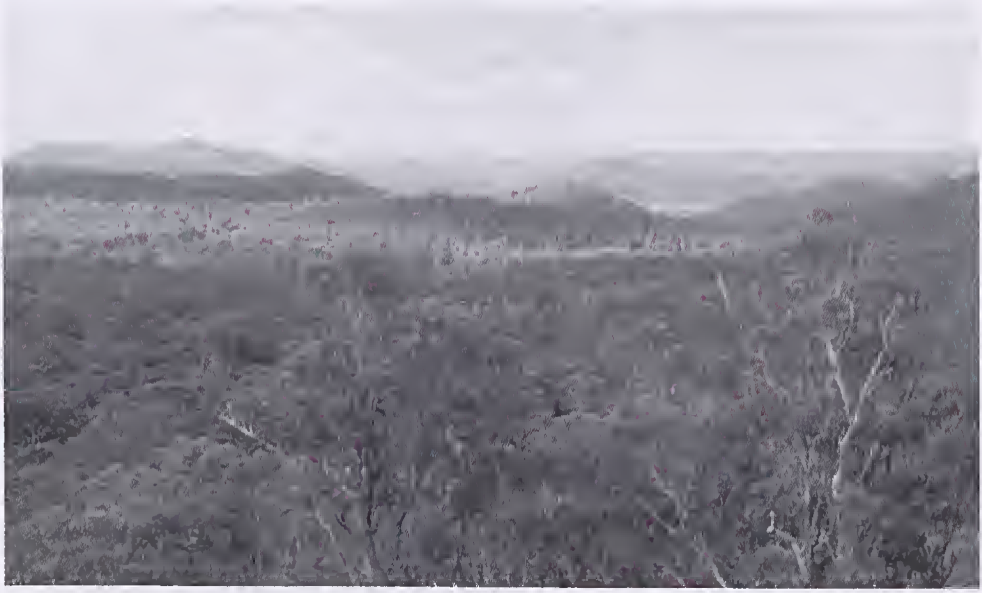

Fig. 35. The largest vegetation remnant in the study area occurs on the leucogranite outcrop north-east of Backwater. This is a key area for conservation because it contains a rich species diversity, a number of rare plant species and a variety of plant communities.

Mount Nobbler

Located three km north-west of Backwater, this granite mountain contains some outstanding stands of community 17, *Eucalyptus obliqua-Eucalyptus nobilis* on protected slopes and community 14 *Eucalyptus radiata-Eucalyptus nobilis-Hovea* sp. A. Some of the footslopes have been recently cleared, even though the ground is rocky.

Happy Valley-Whans Road

The vegetation remnants in this area contained stands of the vulnerable species *Eucalyptus nicholii* and *Eucalyptus youmanii* in community 5 (for example, site 177). Most of this community has been cleared and recent clearing was noted during the survey. *Eucalyptus nicholii* also occurs in a stand of stringybark forest at site 215 west of Boorolong.

Reedy Creek

A stand of *Eucalyptus andrewsii*, *Eucalyptus prava* and *Eucalyptus laevopinea* is present west of Reedy Creek homestead on the steep, rocky hills on an acid volcanic substrate. This has been classified into community 5, although it could be separated from it. While it is restricted in the study area, it is more common to the west.

Travelling stock reserves and roadside reserves

Some of the most important vegetation remnants, containing vegetation that have not been continuously grazed, are located on TSRs or roadsides. These include TSRs along the New England Highway, Rockvale Road, Aberfoyle Road and the Guyra-Tingha Road. The dominant plant species on these TSRs and some sites of conservation significance are documented in Williams and Metcalfe (1991).

An important TSR is Thunderbolts Cave TSR at the Devils Pinch off the New England Highway. This contains a stand of community 1 (site 113) with *Eucalyptus youmanii* and *Pultenaea campbellii*, and regrowth community 3 with a rich diversity of species (site 28). One of the best examples of community 6 (Mountain Gum-Ribbon Gum on basalt) is in the Ebor and Aberfoyle road reserves near the Aberfoyle River (sites 180, 181 and 182). A good patch of community 6 is also found in a crown reserve (site 10) along Wandsworth Road, 3 km south-west of Ben Lomond.

Basalt lagoons

Two small nature reserves (Mother of Ducks and Little Llangothlin) protect parts of two lagoons on basalt (community 24). Little Llangothlin Nature Reserve is listed on RAMSAR as a wetland of international significance. Wetland vegetation of these lagoons remain inadequately reserved and vulnerable. Protection of the wetland on the property Lagoon Farm (site 311) would improve the conservation status of community 24.

Sites with regionally uncommon species

Some sites are important because they contain species that are restricted in their abundance in the study area. Examples include site 87 (Rockvale Road TSR) that contained a tableland occurrence of Grey Box *Eucalyptus moluccana*; sites 80 (Sunnyside Road) and 306 (Little Duval) contained a tufted grassy understorey dominated by the grass *Joycea pallida* and site 221 along the Old Armidale Road that contained the only record for the sedge *Caustis pentandra* in the survey. The recording of the ground orchid, *Caladenia cucullata* at site 133 on 'Wattleridge' was an extension of range for that species.

Other sites included important samples of a community and unusual species. For example, site 235 near the Oban River contained one of the few large stands of *Eucalyptus nova-anglica* encountered during the survey, as well as a northern extension of the grass *Poa clivicola*. Given the impacts of clearing and dieback on communities 8, 9 and 10, any reasonable remnants should be protected.

Discussion

The remaining natural vegetation on the Guyra map sheet is a composite of various sized remnants with different degrees of human-induced disturbance. Overall, the vegetation is a mosaic of grassy open forest and woodland, shrubby open forest, heaths, swamps and lagoons. The distribution of these major types of vegetation is largely determined by physiographic determinants — a combination of parent material and climatic factors. At a finer scale, local site elements such as topography and disturbance history play a modifying role. The largest and most 'natural' remnants occur on the poorest soils and roughest topography including the leucogranite country near Backwater. Most remnants on medium to high nutrient soils are moderately or severely disturbed, at least in their understorey. The tree canopies of plant communities 1–3, 6–10 and 18–19 are, in most cases, composed of secondary regrowth from episodes of clearing in the early 20th and late 19th centuries (Curtis 1989).

Sampling methods

Standards of vegetation survey are discussed in Benson (1995) and Keith and Bedward (1999). It is important that users of vegetation plot data or vegetation maps be aware of the rules that formed the basis of the gathering and interpretation of the data. Scale is one factor that can alter the intensity of survey and detail of mapping.

The vegetation of the study area was sampled on the basis of stratifying the environmental variables of substrate, altitude and landform position. While inspections of rainfall and temperature maps on the NSW National Parks and Wildlife Service geographical information system indicated that rainfall and temperature broadly corresponds to altitude, there are some inconsistencies. For example, there is a marked rainshadow in the south-eastern corner of the study area near Bakers Creek and this variation was not taken into account in stratifying the sampling. It is likely there are inaccuracies in the geology mapping for the region therefore confounding some of the assumptions about sampling major nutrient classes. Also, some plant communities were under-sampled due to the limitations of the LANDSAT-derived vegetation cover GIS layer (Roberts 1992) that was used in selecting sample sites. It identified forest or woodland with a canopy cover of greater than 20%. Therefore, scattered open woodland vegetation, including patches of New England Peppermint *Eucalyptus nova-anglica* (communities 8, 9 and 10), Ribbon Gum *Eucalyptus viminalis* (community 6), and small remnants of less than 5 hectares in area, were not mapped from the LANDSAT image. Although we modified the sampling design to cater for these deficiencies, open vegetation may still have been undersampled. An example is that the small remnants of community 6 were under-sampled in the southern part of the study area. Finally, vegetation remnants in areas distant from roads or tracks were less well sampled than vegetation near roads or tracks.

Classifications of vegetation through numerical analysis can be achieved by either sampling all species in plots or a subset of them. Recording all species takes more time than recording a subset of species. Alternatively, if the aim is to model certain species across a landscape there is advantage in maximising the number of sample plots by minimising the time to sample them ie. by recording a subset of species. Austin et al. (1999) used this strategy in modelling the pre-European distribution of tree and tall shrub species (> 1.5 m) in a survey of the Lachlan region in the NSW wheatbelt.

We recorded all species in plots because we considered that there were benefits of recording full floristic data. Only through the latter can relative rarity be assessed for the total vascular flora of a region. Also, the presence or absence of ground cover and shrub species can be important in determining floristic groupings in a numerical classification. Understorey species should not be underestimated when classifying vegetation.

Mapping scale

The selection of scale depends on the purpose but scale can have major implications for selecting units in the landscape for decision making (Pressey & Logan 1995). We mapped the vegetation of the Guyra 100 000 map sheet area at 1: 25 000 scale. This is a relatively fine scale for regional mapping (Benson 1995), but it was chosen to adequately represent the complexity of the patterns of vegetation, the small size of many vegetation remnants, and the size of properties in the Bioregion. This also matches the topographic map and aerial photographic coverage for the region.

The accompanying published Guyra vegetation map is at 1: 100 000 scale. Such a reduction in scale can lead to a loss of definition of vegetation remnants, and also an amalgamation of floristically classified polygons leading to increased heterogeneity of map units. While these simplifications have been minimised in the published map, vegetation assessments and planning should use the 1: 25 000 scale GIS version of the map. This provides a capacity for generating different map products because each polygon has multiple attributes (viz. type of vegetation, structure, degree of disturbance and understorey condition). Map coverages could be generated, for example, showing the distribution of exotic versus native understorey within certain targeted plant communities.

Plant community classification

Austin and Smith (1989) point out that the community concept of co-occurring species is most relevant to a particular landscape, or region, reflecting its patterns of environmental variables. This highlights the danger of applying a broad-based typology such as 'forest types' (Forestry Commission of NSW 1989) in describing or assessing vegetation in a local or regional context. Most of the 'forest types' that we intuitively attempted to match the plant communities to are much broader in their coverage of geographical distribution and botanical variation.

Understorey variation due to varying degrees of disturbance caused considerable noise in the UPGMA, data output. Some sites were placed into groups counter to intuition because of this variation. The nearest neighbour analysis helped to correct some of these apparent anomalies. This understorey variation caused by different histories of grazing in particular, highlights one limitation of using full floristic plot data to derive vegetation classifications in agricultural landscapes, compared to using it to classify vegetation in more natural landscapes such as conservation reserves. However, when a subset of the floristic data containing only tree species were subjected to UPGMA, the resulting classification was considered to be too simplistic.

The scope of a classification can be important in defining the number of plant communities. Our survey sampled all of the major formations of vegetation across the landscape. We classified one type of heath/mallee (community 21) growing on leucogranite outcrops near Backwater. In contrast, Hunter and Clarke (1998), who restricted their flora survey to vegetation on granitic outcrops in the New England Bioregion, defined three floristic groups on outcrops in the Backwater area.

Patch size also affects the recognition of plant community types. Hunter and Clarke (1998) defined a closed scrub community dominated by *Quintinia sieberi* and *Rapanea* spp. as occurring among leucogranite rock outcrops protected from frequent fire. We only observed this community once and due to its rarity and patch size relative to the scale of the work, it was not sampled nor mapped.

Limited sampling can also affect community classification. For example, an open forest dominated by *Eucalyptus prava* and *Eucalyptus andrewsii* occurs on acid volcanic ridges in a remnant on the western edge of the map sheet (sites 287–289). *Eucalyptus prava* is more common to the west and north-west of the map sheet. It is a canopy co-dominant of plant communities in Torrington State Recreation Area (Clarke et al. 1998) and in Kings Plain National Park (Hunter 2000).

Based on shared understorey species, our sampling grouped this forest into the western tableland stringybark-dominated plant community 5 which is dominated by *Eucalyptus youmanii*, *Eucalyptus andrewsii* and *Eucalpytus subtilior*. It is likely that with more sampling to the west a new plant community would be defined, including the *Eucalyptus prava/Eucalyptus andrewsii* sites 287–289.

Species patterns

Over 150 years of grazing, pasture improvement and clearing of forests has altered the species composition of the vegetation. This has particularly affected plant communities 1, 2, 3, 6, 7, 8, 9 and 19 which occur on high to medium nutrient soils and contain a grassy ground cover.

A number of upright perennial forbs occurring in these communities are regionally rare including *Eryngium ovinum*, *Eryngium vesiculosum*, *Podolepis jaceoides*, *Podolepis neglecta*, *Microseris lanceolata*, *Swainsona monticola*, *Geranium retrorsum* and *Velleia paradoxa*. Tremont (1994) found that tall herbacous plants are susceptible to being grazed out compared to low forbs with flat rosettes. She demonstrated that grazed treatments favoured annual species with reproductive organs at or near ground level between dominant tussocky grasses. Our survey demonstrated that prostrate-leaved forbs such as the introduced *Hypochaeris radicata* or the native *Cymbonotus lawsonianus* were common.

Most species were recorded a few times only. This pattern is similar to that documented in McIntyre et al. (1993) for herbaceous species in the Bioregion. McIntyre (1992) suggests that sparse species occurring in grassy woodlands or in derived native grasslands have been overlooked in threatened species listings. The redlist criteria developed by IUCN (1994) (under revision IUCN 1999) overcomes this to some extent, as susceptible species can be identified if they are declining.

The ubiquitous stringybark communities 2 and 3 are the most widespread plant communities in the study area. Both stringybark species *Eucalyptus caliginosa* and *Eucalyptus laevopinea* occur on various substrates and aspects but both species tend to grow on ridges or slopes rather than in valley bottoms. Since hybridisation between these species may occur, it is difficult to detect clear patterns in their distribution. Significant differences of distribution occur due to substrate and aspects. Broad-leaved Stringybark, *Eucalyptus caliginosa*, is widespread on siliceous sedimentary substrates in the south around Armidale, on siliceous acid volcanic substrate in the north-west of the study area, on granite and on leucogranite north of Backwater as a co-dominant in quite different floristic assemblages from those on sediments and acid volcanics. Silver-topped Stringybark, *Eucalyptus laevopinea*, tends to occur on steep, well drained, protected (south or east facing) slopes (sometimes enriched by basalt above). It also commonly occurs on acid volcanic, sedimentary and basaltic substrates but is less common on leucogranite and granite.

The databased survey data provides a basis for further analysis of species patterns and modelling of species distribution.

Modifications induced by European land use

A thorough account of the changes to the vegetation on the Northern Tablelands since European settlement is given in Curtis (1989), although much of his discussion deals with regions outside the Guyra 1: 100 000 map sheet study area.

Clearing, grazing and soil erosion

As early as the 1870s people were alarmed at the effect of clearing on the landscape. Mrs Charles Meredith (1844), referring to clearing near Sydney, wrote:

'The system of clearing here by the total destruction of every tree and shrub gives a most bare, raw and ugly appearance to a new place'.

Today, approximately 26% of the native tree cover remains in the study area. Much of this is regrowth forest after past clearing or logging (Nadolny 1995). Clearing has concentrated on the more fertile soils and flatter terrain. Relatively intact plant communities are 12, 13, 14, 15, 17, 20, 21 and 22. Most of these are confined to poor soils on leucogranite in the Backwater region. However, clearing of marginal agricultural lands on granite and leucogranite for hobby farms has continued up to the present.

The communities on higher nutrient soils (1, 3, 6, 7, 8, 9, 10, 19) are mostly cleared and remain as small remnants. The NSW land cover study by ERIC (1998) revealed that very little clearing (50 ha/year) took place in the study area between 1995–97. This was possibly due to low commodity prices for wool and meat.

Some communities are estimated to have been cleared to less than 20% of their original extent, for example Blakely's Red Gum-Yellow Box on sediments (community 1), Mountain Gum-Ribbon Gum on the Guyra basalt plateau (community 6), and communities 8 and 9 containing New England Peppermint. Furthermore, communities 1, 2, 8, 9, 10 and 18 have been extensively ringbarked in the past (Fig. 36) and affected by dieback.

Over-clearing and subsequent over-grazing has led to soil erosion in some places (Fig. 37). Gale et al. (1997) found that the deposition rate of soil into Llangothlin Lagoon accelerated after the introduction of stock by Europeans in the Guyra area in 1837. These authors postulate that much of the topsoil of the lagoon's catchment was eroded within 25 years of the arrival of Europeans.

Continuous grazing of most grassy woodland or forest remnants (communities 1, 2, 3, 6–10 & 19) has probably led to a depletion of the shrub understorey and a lack of regeneration of trees (Curtis 1989). Norton (1876) noted patches of wattle (*Acacia*) among white gums (*Eucalyptus viminalis* or *E. pauciflora*) and New England Peppermint near Glen Innes in the 1850s, and the Government botanist (Maiden 1898) noted *Acacia* as being common in the understorey in the region. During our survey wattle was rarely abundant in sample plots in the grassy woodland communities — although it was more common on roadsides or in travelling stock reserves that are not continuously grazed. Overall, wattle appears to have declined substantially since European settlement.

Many native grass and forb species have declined under high grazing pressure because of their growth habit or palatability. In extreme cases the natural ground cover has been completely altered through ploughing and sowing of exotic species creating an appearance of a manicured park (Fig. 38). Both Whalley et al. (1978) and McIntyre et al. (1993) report that stock grazing has produced a shift from tall tussocky grass species, such as *Themeda australis* and *Sorghum leiocladum*, to more prostrate, shorter

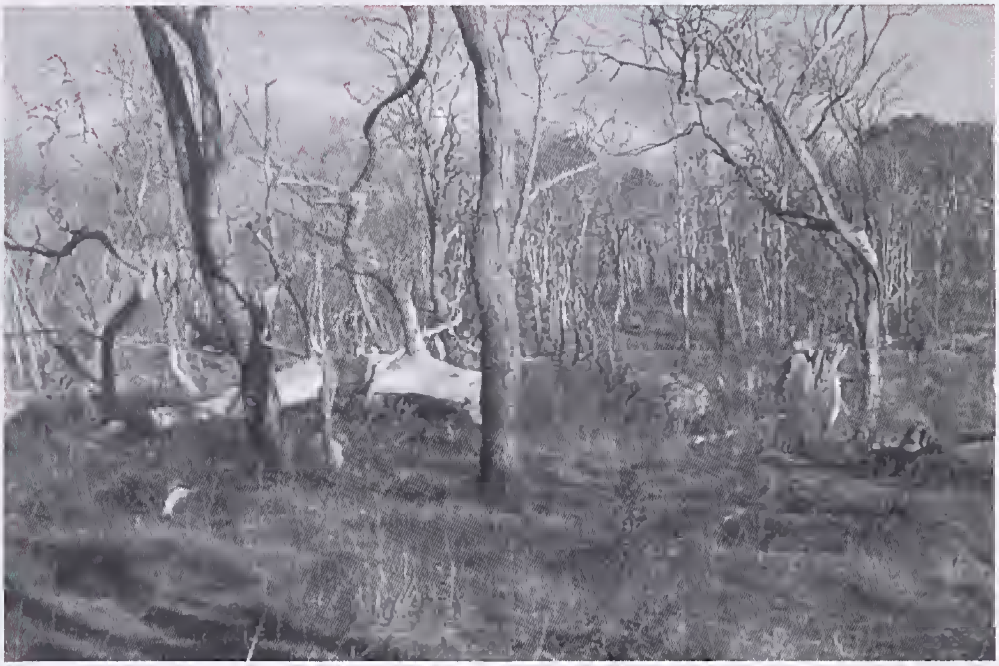

Fig. 36. Large areas for forest on the New England Tableland Bioregion have been ringbarked such as this stand of *Eucalyptus nova-anglica-Eucalyptus pauciflora* open forest (community 10) north of Backwater.

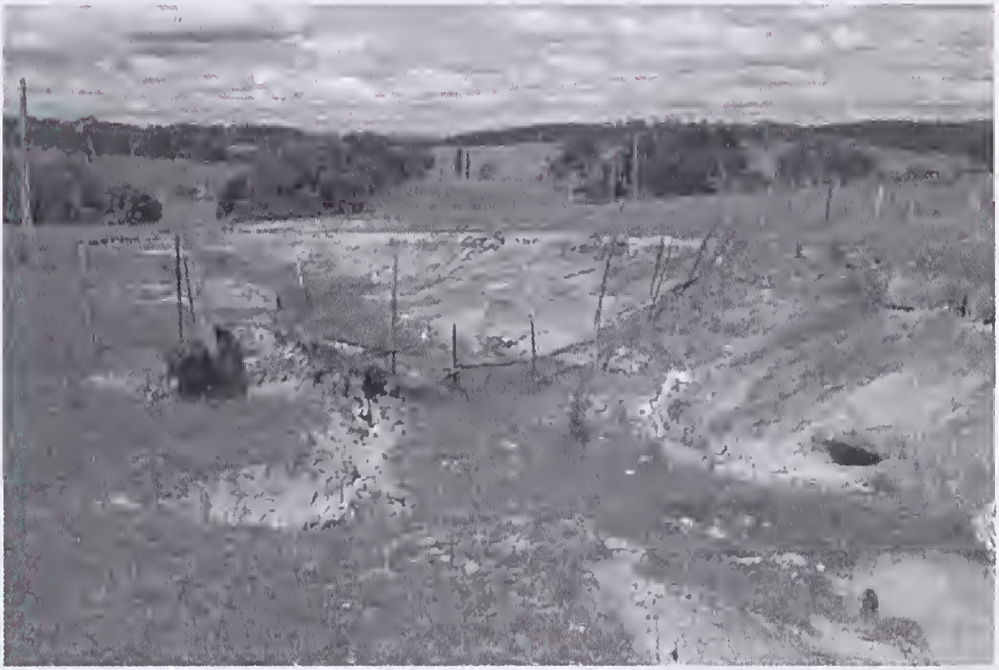

Fig. 37. Clearing of native vegetation followed by heavy grazing has led to gully erosion in some places such as this gully at the foot of Mount Hourigan.

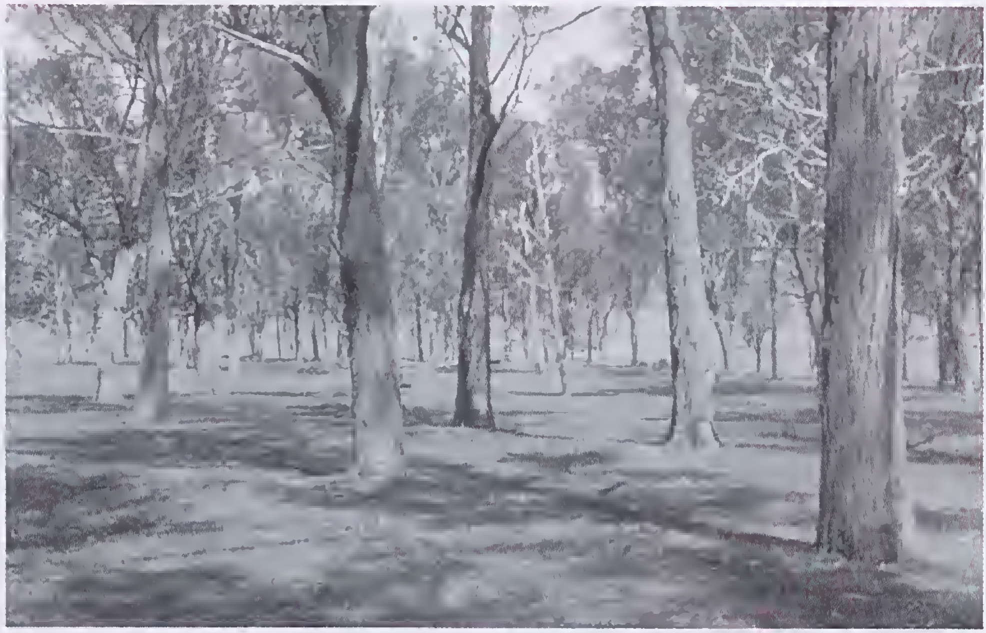

Fig. 38. The ground cover in many forest remnants has been replaced by exotic species. This is illustrated here in this *Eucalyptus laevopinea* forest on basalt north-west of Armidale where the ground cover is dominated by the exotic grasses *Hordeum leporinum*, *Lolium perenne* and *Bromus* spp.

species. They note that less palatable native grasses such as *Poa sieberiana* may increase in the presence of grazing and the removal of competitors. Our survey data support this view as *Poa sieberiana* was the most common species recorded in the 312 sample plots.

Fragmentation

Clearing of two thirds of the woody vegetation along with episodes of dieback have yielded a fragmented landscape. However, the degree of fragmentation is generally less pronounced than that in the Western Australian and eastern Australian wheatbelts (see papers in Saunders et al. 1987). Studies on fragmentation show that when 50% of vegetation is cleared, connectivity between remnants is broken (Dawson 1994). When more than 70% of a landscape is cleared, the small patches of bush between larger remnants tend to disappear (Andren 1994). This leads to a significant decline in the population of some species because their dispersability across the landscape diminishes as distance between remnants increases (Andren 1994, Schwartz 1992).

The theory of island biogeography of species diversity in relation to habitat area and spatial arrangement of habitats (MacArthur & Wilson 1967) is more applicable when the matrix between habitat patches is distinct (Diamond 1981). It is postulated that habitat sensitive plant or animal species will not persist or cross altered countryside (Dawson 1994). However, some less sensitive species will. Native pasture and isolated trees commonly occur between vegetation remnants in the New England Bioregion. For this reason McIntyre and Barrett (1992) described the Bioregion as a variegated landscape because diffuse boundaries exist between forest remnants and pasture land compared to the sharp boundaries encountered in crop lands or on oceanic islands. However, since we did not map native pastures or isolated clumps of trees less than one hectare in size, any use of the vegetation map for predicting the impacts of fragmentation on certain species need to take these limitations into account.

Assuming that some native species live in substantially modified habitats, vegetation management should not be restricted to preserving large remnants. Rather, the whole landscape should be managed sympathetically. Nevertheless, it is likely that species of animals and plants with low populations, low reproductive potential, poor dispersal mechanisms and large fluctuations in their populations would be most susceptible to extinctions in the most fragmented parts of the study area. These would include areas covered by communities 1, 5, 6, 7, 8, 9, 10, and 19 which have been reduced to less than 30% of their pre-clearing extent.

In a study of vegetation remnants near Armidale, Barrett et al. (1994) found that 104 of the 137 bird species recorded were threatened by fragmentation and structural change of the vegetation. Some bird species such as the Red-browed Treecreeper were restricted to large (> 400 ha) remnants, while other species were recorded in smaller remnants. Reid (1999) supported these findings for woodland bird species occurring on the Southern Tablelands of NSW. He found that size, complexity and spatial arrangement of vegetation remnants are critical factors for the survival of many woodland birds. Barrett et al. (1994) concluded that to protect what is left of the New England avifauna, vegetation remnants of various sizes need to be maintained, a range of tree age classes need to be present, and the understorey needs to be managed to encourage regrowth of shrubs. This may require the judicious use of fire to stimulate the germination of some shrubs species and controlling stock numbers to allow for their growth to maturity.

Enhancing corridors may allow species to recolonise areas through immigration (Diamond & May 1976) where stochastic events (fire, drought, flood, changes in herbivory or predation) may have led to their localised extinction.

Weeds

Invasive plants are not as critical a threat to native vegetation in the study area compared with other parts of eastern Australia. There are numerous pasture weed species. Some of these dominate the ground cover and invade forest remnants that adjoin pastures. Only a small proportion of the 146 exotic species recorded are 'problem' weeds. *Hypochaeris radicata* was the most commonly recorded exotic species.

The long lived shrub, Hawthorne (*Crataegus monogyna*), is a weed in some places — particularly near Armidale. The fruit of this species is dispersed by birds such as the Pied Currawong (Bass 1989). Privet (*Ligustrum vulgare)* has seeded into forest remnants close to settlements but is less abundant than Hawthorne. Blackberry (*Rubus ulmifolius*) invades riverine vegetation (community 23) by dispersing along watercourses. St John's Wort (*Hypericum perforatum)* is common in some disturbed pastures and forests such at site 29 along Sunnyside Road north of Armidale. Although we did not record African Love Grass *(Eragrostis curvula)*, it is present and increasing in abundance in the Bioregion (C. Nadolny pers. comm.). It is becoming a major weed species in other places such as western Sydney and on the Southern Tablelands. Both *Hypericum perforatum* and *Eragrostis curvula* produce large quantities of small dispersible seeds and therefore may easily increase in abundance.

Dieback

Dieback is a complex phenomenon that has caused the death of millions of trees in rural areas of south-eastern Australia (Landsberg & Wylie 1988). The Northern Tablelands gained national attention in the late 1970s and 1980s due to a major episode of dieback that killed millions of trees (Nadolny 1988). Several studies on dieback have concentrated on the Northern Tablelands (for example Williams & Nadolny 1981, Mackay et al. 1984, Jones et al. 1990). Nadolny (1995) summarised the current viewpoints about the causes of dieback in the region:

- Defoliation by scarab beetles was a major cause of dieback on the Northern Tablelands in the 1970s–80s. It is postulated these beetles may have increased in numbers due to a combination of favourable climatic conditions, the existence of more feed for their larval stage in improved pasture, reduced predators such as birds, bandicoots and parasitic wasps and an increase in the nutrition of the foliage of trees due to livestock excrement and fertilizer;
- Drought can cause water stress in trees making them more susceptible to infections (White 1986);
- Fungal infections can occur in trees damaged by storms. Isolated trees in paddocks are more susceptible to storm damage;
- Increased soil salinity and water stress during drought.

In the study area dieback has most affected:

- Community 1: *Eucalyptus blakelyi-Eucalyptus melliodora* open forest on sediments around Armidale;
- Community 2: *Eucalyptus caliginosa* open forest in remnants east of Armidale along the Chandler Road. In other places stringybark trees were little affected by dieback;
- Community 8: *Eucalyptus nova-anglica* open forest on basalt (Fig. 18);
- Community 9: *Eucalyptus nova-anglica* open forest on sediments around Armidale and Boorolong. This has been the most affected community with whole valleys losing all of their trees (Williams & Nadolny 1981, Nadolny 1988);
- Community 10: *Eucalyptus nova-anglica-Eucalyptus pauciflora* woodland on granite and leucogranite near Backwater and along the Oban River;
- Community 18: *Eucalyptus radiata* subsp. *sejuncta-Eucalyptus acaciiformis* open forest on granite near Llangothlin, Rockvale Road, Days Trig and Wards Mistake.

Logging

Even where the vegetation has survived the initial phases of land clearing, continued logging has altered the structure of the forest and now few old trees remain. This is evident in state forests and on private forested land. Logging has particularly had an impact on communities 2, 3, 13 and 17. A recent trend towards wood heating in Armidale has led to increased cutting of trees for firewood and a resource depletion

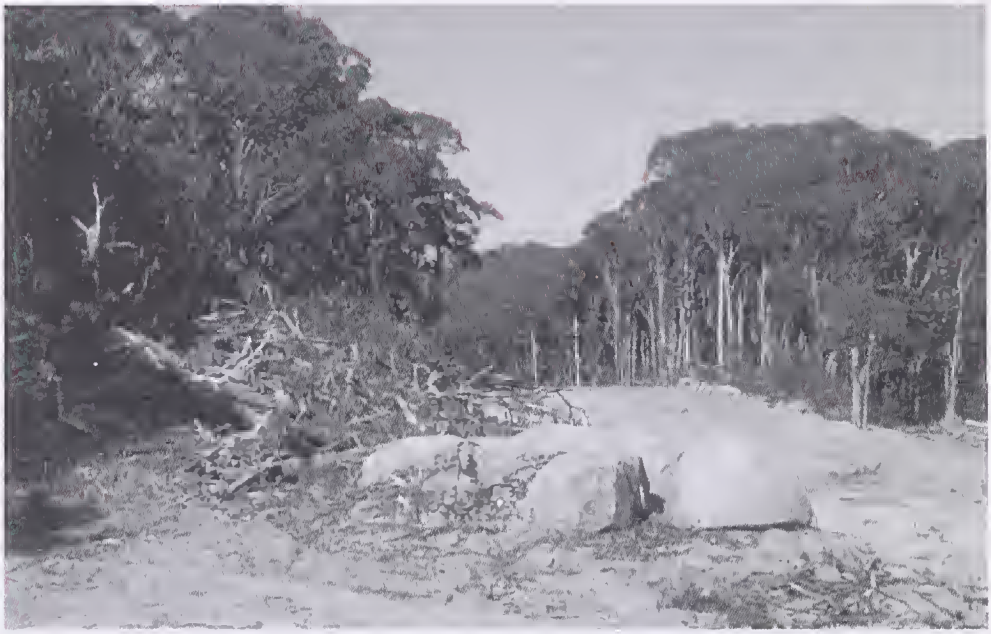

Fig. 39. Subdivision and road construction on non-agricultural private land is threatening some of the largest vegetation remnants in the study area, such as this *Eucalyptus radiata* subsp. *sejuncta*-*Eucalyptus nobilis* (community 15) forest on leucogranite near site 34 at Mount Mitchell north of the Sara River.

(Wall & Reid 1993). This is impacting on plant communities that contain poor sawlog timber that had not previously been subject to sawlog extraction. An example of this is community 5 that occurs on acid volcanic substrates on the drier, western side of the study area.

Subdivision

One of the main threats to some of the larger vegetation remnants on rougher terrain composed of granite, acid volcanic or leucogranite substrates is subdivision for hobby farms. Areas around Mount Mitchell have been subdivided into 25 and 100 ha blocks with wide roads being pushed through some of the largest vegetation remnants in the study area (Fig. 39). The owners of these small bush blocks often clear part or all of them and introduce stock and other domestic animals. In contrast, some subdivision within a 20 km radius of Armidale may be having a positive effect on regeneration of plant communities 1, 2, 3 and 9 because grazing has been removed or limited.

Draining wetlands

Draining or impounding of lagoons has severely depleted the abundance of the wetland plant community 24. This could be considered a vulnerable plant community. Assessments by D. Bell (pers. comm.) reveal that only six of an original estimated 30 swamps in the study area remain in good condition. Most of these swamps occurred on the basalt plateau near Guyra, with a few near Armidale. Most have been drained for conversion to pasture, some have been impounded to form dams for stock. One of the best remaining wetlands is Lagoon Farm near Black Mountain (Fig. 33). This wetland, along with the surrounding Snowgum woodland, ranks as one of the highest priority areas for conservation in the study area.

Changed fire regimes

Due to the degree of modification of the landscape, and a lack of documentation of past fires or Aboriginal burning practices, it is not possible to decipher precisely what were the pre-European fire regimes in the different plant communities in the study area. Presumably, moister forests with shrubby understoreys (for example, communities 17 and 18) would not have been subject to frequent fires. Some of the shrublands and dry sclerophyll forests on acid volcanic and leucogranite substrates may have been subjected to intense fires every 10–30 years. The grassy woodland communities may have been subjected to a mosaic pattern of less intense and relatively frequent burning by Aborigines.

Some plant species in the small, isolated remnants may have declined due to lack of burning. Grasses such as *Themeda australis* are known to respond well to fire (Lunt 1990). Many remnants are surrounded by improved pastures that rarely, if ever, burn. The isolation of remnants from larger stands of forest due to clearing has possibly led to a decrease in fire frequency. This may have affected populations species adapted to regenerate after fire (e.g. legumes). Intense fire can still occur in the larger remnants. Most of Warra State Forest (now partly reserved as Warra National Park) was burnt by an intense fire in January 1994 (NSW State Forests pers. comm.). This intense fire stimulated the germination of the rare species *Muehlenbeckia costata* and *Monotaxis macrophylla*.

Vegetation management

The remnant grassy woodland communities on more fertile soils are significantly influenced by grazing pressure and management of surrounding lands. The ground cover of New England Peppermint (communities 8, 9 & 10) and Ribbon Gum/ Mountain Gum (communities 6 and 7) remnants are often dominated by exotic pasture species and tree regeneration may be suppressed due to grazing pressure. There are few sites within these communities that contain a shrub layer. One aim of management should be to induce the germination of species of wattle through fire and protection from continuous grazing. Morgan and Terrey (1990) recommended the destocking of state forests in the region.

Some disturbances to native vegetation are direct and severe. These include impoundment of lagoons, clearing of woody vegetation and ploughing of native ground cover. These processes can be controlled through regulations, incentives and education. Other disturbances are more indirect and more difficult to control. For example, riparian vegetation (community 23) is being degraded through stock trampling river banks to access water, weeds invading via creeklines and changes in water quantity and quality due to the removal of vegetation in catchments and pollution from a range of sources. Controlling these threats requires both catchment management (controlling pollution) and local management (piping water to stock in paddocks distant from creeklines).

Although some plant communities have been severely cleared, modified and fragmented in the study area, others still contain large numbers of remnants that are linked by corridors. The role of corridors has been subject to a large debate in the literature but most commentators consider corridors have a role in maintaining species in a landscape (see review by Dawson 1994). Management should aim to maintain these remnants as they form a source for 'natural' revegetation. Conservative land management (Nadolny 1995) of low grazing pressure and less pasture improvement would assist with restoring grassy forest and woodland communities. The cost-benefits of further pasture improvement in areas with poorer soils is questionable (Nadolny 1998). Sustainable agricultural practices that use a diversity of approaches to grazing and cropping may meet some of the requirements of protecting herbaceous plant species in the Bioregion (McIntyre 1994).

Revegetation through the planting of indigenous trees, shrubs and ground cover species is appropriate in areas that have been extensively cleared, degraded or severely affected by dieback (Barrett & Ford 1993). In the study area this mainly includes plant communities containing Blakely's Red Gum, Yellow Box and New England Peppermint as well as riparian vegetation. However, revegetation is a very costly solution, so if it is to be undertaken it should be based on the best information available. It should be undertaken in places where perhaps 80% of the vegetation has been cleared. While revegetation programs may never restore the vegetation and associated biodiversity to a pre-clearing form, some studies show that tree planting can increase biodiversity, probably due to habitat complexity. For example, Chilcott et al. (1997) recorded more microarthropod species in windbreaks than in open pasture. Revegetation may also redress the problem of dieback in plant communities where the remnant patch sizes are small and vulnerable, or the species themselves are inherently susceptible (Jones et al. 1990).

Revegetation should not simply target critical habitats or species, but should be undertaken with landscape processes in mind such as establishing corridors for wildlife movement, or increasing the size of existing remnants to increase the populations and viability of the species in them.

Conservation

The conservation and management of the natural biota is dependent on knowledge of the resource and ecosystem dynamics. This study has begun to address these aims by defining and mapping 24 plant communities and quantitatively correlating them with physical explanatory variables such as geology and altitude. Nationally, State or regionally rare or threatened species are listed and discussed. Sites of botanical significance are listed and proportions remaining of plant communities are estimated. These data can be used for planning the protection of key floristic elements in the landscape, but will not address fauna or abiotic values.

The five conservation reserves totalling 1904 ha managed by the NSW National Parks and Wildlife Service, account for 0.72% of the study area. Two reserves centre on deflation lagoons on the basalt plateau near the town of Guyra-Mother of Ducks Lagoon Nature Reserve (102 ha) and Little Llangothlin Nature Reserve (254 ha). Three forest conservation reserves were established as a consequence of the 1998 Comprehensive Regional Assessment of the forests of north-eastern NSW. They mainly sample stringybark communities. The former Warra Flora Reserve and Warra State Forest were subsumed into the Warra National Park (1918 ha). Most of this National Park falls on the Glen Innes map sheet to the north, with only 440 ha within the study area. Mount Duval State Forest was dedicated as the Duval Nature Reserve (243 ha) and Boorolong State Forest was dedicated as Boorolong Nature Reserve (865 ha).

The proportion of the study area reserved (0.7%) is less than one tenth for the New England Bioregion as a whole (7.5% in Pressey et al. in press and Benson 1999). Most of the area reserved in the NET Bioregion is located on its eastern edge bordering on the rugged terrain of the eastern escarpment with other reserves concentrated on granite or acid volcanic substrates in the west and north (Fig. 34). The central part of the bioregion is more extensively cleared and contains far less reserves. This highlights the need to address reservation at finer scales than bioregions, such as at the province or landscape level of classification used in Pressey et al. (in press) or at the plant community level (Benson 1989).

Of the 24 plant communities 16 are sampled in reserves in the study area. However, only four of these have more than 5% of their estimated pre-European extent reserved in the study area (Table 4). The remainder are very poorly or poorly reserved, with less than 5% of their pre-European extent reserved (Table 4). No communities are adequately reserved as defined in this paper (> 10% of pre-European extent protected). Some communities may have a different degree of reservation over their full range but cannot be established until their range is mapped. It is known, for example that community 17 (*Eucalyptus obliqua-E. nobilis*) is well protected in reserves such as Werrikimbee, Barrington Tops and Ben Halls Gap National Parks. Alternatively, the *Eucalyptus nova-anglica* communities 8–10 are known by the authors not to be well protected in reserves outside the study area.

There is little scope for conservation through reservation in areas where most of the vegetation remains in small, isolated remnants of varying vigour, although some TSRs provide scope for protecting reasonable-sized remnants (Williams & Metcalfe 1991). Only scattered remnants of communities 1–3, 6–10, 19 and 24 remain. For these communities it will not be possible to meet the JANIS (1996) criterion that 15% of the pre-European extent of ecological communities should be protected in conservation reserves. However, if the naturally vegetated part of 'Wattleridge' and portion 14 Parish Hall were reserved, this criterion could be met or exceeded for the leucogranite plant communities 11, 12, 14, 15, 20–22. This would enlarge the present Warra National Park and would also protect a large number of rare species. Other large patches of vegetation where reserves could be established include: Avondale State Forest, parts of Days Ridge, Mount Nobbler and areas on acid volcanic substrate near Reedy Creek.

Depending on their status outside the study area, plant communities 1, 6, 7, 8, 9, 10 and 24 are under long term threat and may warrant listing as endangered ecological communities under the NSW Threatened Species Conservation Act 1996. Certainly, further clearing of them should be discouraged.

The future of the native flora in this rural landscape will largely depend on appropriate management of private land and on public lands such as state forests, roadsides and TSRs. Five key conservation programs are required:

- controls on clearing and logging;
- pursual of conservation or property agreements over remnants on private land;
- management of the understorey in forest remnants including appropriate grazing and fire regimes;
- control of problem weed species;
- revegetation of over-cleared areas such as valley bottoms on the basalt plateau.

These programs could be designed and coordinated through a regional vegetation management plan under the NSW Native Vegetation Conservation Act. This study provides baseline data for the design and implementation of vegetation planning for the Guyra 1: 100 000 map sheet area. These data are also comprehensive enough to be incorporated into modelling procedures (Ferrier & Watson 1997) for single species restoration projects.

The future of the remnant vegetation in the 'variegated' landscapes of the New England Bioregion will largely depend on the attitudes of local people to landscape

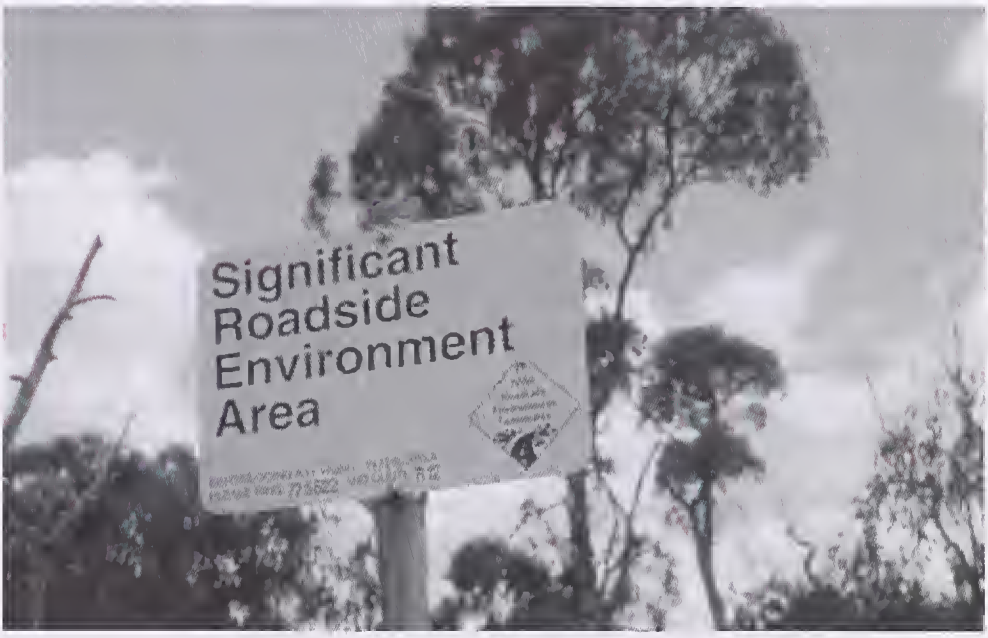

Fig. 40. Important stands of roadside vegetation are being sign-posted by local governments in the study area. This helps to alert the public and council workers about the presence of this vegetation and can help to protect it from disturbances such as road widening.

management. There are some encouraging signs as more landholders discover the benefits of maintaining native vegetation cover (summarized in Gillespie 2000). The signposting of significant vegetation on public roadsides by Dumaresq Shire Council (Fig. 40) is an example of the active and positive role that local government and local communities can take in nature conservation.

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Appendix 1. Plant species list with their occurrence in plant communities 1–24 for the Guyra 1: 100 000 map sheet.

Communities 6 & 7 are combined and community 8 was not sampled. The total of 889 taxa is composed of 664 taxa from 312 sites, 17 taxa recorded outside quadrats marked 'A', 43 taxa from NSW National Herbarium database marked 'B' (taxa not collected within the last 40 years are indicated by the year of the last collection), 119 taxa from the University of New England Herbarium (Department of Botany) database marked 'C', 3 orchid taxa from Peter Metcalfe (pers. comm.) marked 'D', 35 wetland taxa from Dorothy Bell (pers. comm.) marked 'E', 2 taxa from NSW NPWS ROTAP database marked 'F' and 6 rare species collected from the Backwater leucogranite by J.T. Hunter (pers. comm. 1996) marked 'G'. The Rare or Threatened Australian Plant list (Briggs & Leigh 1995) code is listed in parentheses: **E** = Endangered, **V** = Vulnerable; **R** = Rare; **K** = Poorly Known. Species listed under the NSW Threatened Species Conservation Act are coded: **e** = endangered, **v** = vulnerable. Introduced species are marked with an asterisk.

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
BRYOPHYTES																						
Sphagnaceae																						
Sphagnum cristatum																		4				
PTERIDOPHYTES																						
Adiantaceae																						
Adiantum aethiopicum		1	2	1				1	1	1			1	1	10	1					11	
Aspleniaceae																						
Asplenium australasicum ^{A}															+							
Asplenium flabellifolium	2	5	9	1		4				1					19	4			1		3	
Azollaceae																						
Azolla filiculoides ^{E}																						
Blechnaceae																						
Blechnum cartilagineum										1					3							
Blechnum minus ^{B,1930}																						
Blechnum nudum															1						1	
Blechnum wattsii																					2	
Doodia aspera															3							
Doodia caudata			1						1	2				1	3						1	
Cyatheaceae																						
Cyathea australis ^{A}															+							

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Davalliaceae																						
Davallia solida var. *pyxidata*										+					1				1			
Dennstaedtiaceae																						
Pteridium esculentum		10	7	3	3	17	1	8	13	12	1	2	9	5	33	18		1			8	
Dicksoniaceae																						
Calochlaena dubia										4			1		6							
Dicksonia antarctica											+				1							
Dryopteridaceae																						
Polystichum formosum						1																
Gleicheniaceae																						
Gleichenia dicarpa										1								2				
Isoetaceae																						
Isoetes muelleri^{C}																						
Lindsaeaceae																						
Lindsaea microphylla										2												
Lindsaea linearis																				1		
Lycopodiaceae																						
Lycopodiella lateralis																		1				
Marsileaceae																						
Marsilea costulifera^{E}																						
Marsilea hirsuta ^{C}																						
Marsilea mutica ^{C}																						
Ophioglossaceae																						
Botrychium australe								1					1			1						
Ophioglossum lusitanicum			1																			
Polypodiaceae																						
Pyrrosia rupestris						1				2			1		7	1			1			

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Psilotaceae																						
Psilotum nudum c																						
Sinopteridaceae																						
Cheilanthes distans		1	1											3								
Cheilanthes sieberi subsp. *sieberi*	12	8	18	2	8	2		2	1	2				3	2	1	1		2		3	
Pellaea nana	2	3	8		1	2								2	2						1	
GYMNOSPERMS																						
Cupressaceae																						
Callitris oblonga subsp. *parva* **(V, v)**													1								2	
ANGIOSPERMS																						
Acanthaceae																						
Brunoniella australis		1																				
Brunoniella pumilio										1												
Alismataceae																						
Damasonium minus c																						
Amaranthaceae																						
Alternanthera denticulata																					3	
Alternanthera sp. A	2		1																			
Anthericaceae																						
Caesia parviflora	+	1																				
Dichopogon fimbriatus	2	3	5	3	2	6	1	2	1			1			6	1	1	1				
Dichopogon strictus	1																1					
Laxmannia compacta c																						
Laxmannia gracilis			1																1			
Thysanotus tuberosus subsp. *tuberosus*	1						1	1														
Tricoryne elatior	2	1	2													1						
Apiaceae																						
**Ammi majus* c																						

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Apiaceae cont.																						
**Berula erecta* ^{A}			+																			
Centella asiatica ^{E}																						
**Ciclospermum leptophyllum*																					1	
**Conium maculatum* ^{B}																						
Daucus glochidiatus	2	1	7			4							2	1	4							
Daucus glochidiatus form C		1																				
Daucus glochidiatus form F	1	2	1		1										1							
Eryngium ovinum ^{C}																						
Eryngium vesiculosum						1									7	5						
Hydrocotyle geraniifolia		1				1		2	1	1			3		18	8		1	1		2	
Hydrocotyle laxiflora	8	22	26	2	2	21	3	6	3	2			5	4	21	14	2	1			1	
Hydrocotyle peduncularis										1												
Hydrocotyle tripartita																1					9	4
Lilaeopsis polyantha																						1
Oreomyrrhis eriopoda		1	1											1	1	2						
Platysace ericoides									1	7		3	1		1				2	2		
Platysace lanceolata										1									4			
Trachymene anisocarpa								1		1			1		1				1			
Trachymene incisa subsp. *incisa*	1				2	2			2	3			3	1	2	4			2			
Araliaceae																						
Polyscias sambucifolia subsp. A		1		1					3	5		1	3		3	2			1			
Asphodeliaceae																						
Bulbine bulbosa	4	1	9		1	5	2	2	2				3	2	3							
Asteraceae																						
Ammobium alatum	2	1	2			8	1	1							1						4	
**Anthemis cotula* ^{C}																						
**Aster subulatus* ^{C}																						
**Bidens pilosa*						1																

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Brachyscome aculeata					1	1							1									
Brachyscome angustifolia var. *heterophylla*	4	5	4		2	1			2				1		1	2	1	1				
Brachyscome dissectifolia ^{C}																						
Brachyscome graminea ^{C}																						
Brachyscome heterodonta var. *heterodonta*	2	2																				
Brachyscome microcarpa		2	1	1	6	1			1	4	2	3	3	1	6	6					2	
Brachyscome nova-anglica		5	3	2		6		1	8	3			7		8	3			1		1	
Brachyscome procumbens	1	1	3	1											1							
Brachyscome radicans																						4
Brachyscome scapigera		1			1	1											1	1				
Brachyscome spathulata		2	5	1					1						4			1				
Brachyscome stuartii						1													2		1	
Brachyscome tenuiscapa var. *pubescens*		3			1			3	2	2				3	1	3			1			
Bracteantha bracteata		3				8		2	3	2			3		3	1	1	1			3	
Calotis cuneifolia	3	5	3	1		2											1					
Calotis dentex				1					1	1												
Calotis lappulacea ^{C}																						
**Carthamus lanatus* ^{C}																						
Cassinia compacta ^{C}																						
Cassinia laevis		1																				
Cassinia quinquefaria	6	7	8	2	1		1															
Cassinia uncata					2																	
Centipeda cunninghamii ^{E}																						
Centipeda minima ^{C}																						
Chrysocephalum apiculatum	6	6	1		4	4	2	3	6	5		2	7	2		2	3			1	1	
**Cirsium vulgare*	3	13	15		2	18	2	1					1		16	5	1	1			6	
**Conyza albida*	1	3	3		1	8		3	3				3	2	3	5					9	1
**Conyza bonariensis*	1														1							
**Conyza canadensis* var. *canadensis* ^{C}																						

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Cotula australis	2	1	5																			
Craspedia variabilis		1				6	2					1	1	1	4	3		2				
*Crepis capillaris	2			1		1		1							2						3	
Cymbonotus lawsonianus	4	8	12			2	3								1							
Euchiton gymnocephalus	6	22	21	3	4	7	1	2	6	3			7	1	15	10	1				4	
Euchiton involucratus						1							1									2
Euchiton sphaericus	1	2				2																
*Gamochaeta americana	3							1	1												1	
*Gamochaeta spicata	1		1			1	1									1					2	
Helichrysum rutidolepis									2	1			2		1						2	
Helichrysum scorpioides		1				1		1	1						2						1	
*Hypochaeris glabra	1	5	6	1												1						
*Hypochaeris radicata	13	36	36	6	15	20	6	9	11	6	2	1	9	5	29	20	3	2	1		13	
Lagenifera gracilis			1																			
Lagenifera stipitata	5	6	10		2	1		1		1					8	2						
Leptorhynchos squamatus subsp. A	3	2			1	3	2	1														
*Leucanthemum vulgare			1		1	6	1	1													3	
Leucochrysum albicans var. _albicans_						1		1								1						
*Matricaria perforata ^{c}																						
Microseris lanceolata	1	1				1																
Olearia alpicola ^{c}																						
Olearia argophylla															6	1						
Olearia cydoniifolia ^{c}																						
Olearia elliptica	1	3	3																			
Olearia erubescens				1	1																	
Olearia oppositifolia												2			5	1						
Olearia ramosissima		1							1	1												
Olearia ramulosa										1										1		
Olearia rosmarinifolia																					1	

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Olearia viscidula	2	4	4	5	1		1								1	1						
Ozothamnus diosmifolius			2										1			1	2		1			
Ozothamnus obcordatus ^{C}																						
**Picris hieracioides*		1				2							1									
Podolepis hieracioides						1			1	1		1										
Podolepis jaceoides ^{C}																						
Podolepis neglecta ^{B}																						
Pseudognaphalium luteoalbum ^{E}																						
Rhodanthe anthemoides					2		1															
Senecio bipinnatisectus						2																
Senecio diaschides	1	3	2	1	2	5			2				1	1	2	2	1	1			1	
Senecio gunnii															1							
Senecio hispidulus var. *hispidulus*		2	2	1		1			1						3						1	
Senecio lautus subsp. *lanceolatus*													1								1	
Senecio linearifolius						1																
Senecio quadridentatus		1	2	3		1									1						1	
Senecio sp. E	1	7	8	2		4		1	2	4	1		9	3	23	12	1	1	1		2	
Sigesbeckia australiensis						1									2							
**Sigesbeckia orientalis*			1																			
**Silybum marianum* ^{C}																						
Solenogyne bellioides	2	4	4		1	1				1					1	2					2	
Solenogyne dominii		1					1															
Solenogyne gunnii		2	2												3	1						
**Sonchus asper* subsp. *glaucescens*	1	2	4			2		1													1	
**Sonchus oleraceus*	1		1																			
Stuartina muelleri ^{C}																						
**Taraxacum officinale*	4	14	16		1	12	2	1			1				9	6	1				3	
**Tripleurospermum inodorum*						1																
Triptilodiscus pygmaeus ^{A}	+																					

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Asteraceae cont.																						
Vittadinia cervicularis var. *subcervicularis*			1																			
Vittadinia cuneata	4	3	8		1		1		1					2		1						
Vittadinia dissecta var. *hirta* C																						
Vittadinia muelleri	3						1															
**Xanthium spinosum* E																						
Bignoniaceae																						
Pandorea pandorana			2																			
Boraginaceae																						
Cynoglossum australe	3	6	7	1		8		3						1	3	2					1	
**Echium plantagineum* C																						
Myosotis australis	1				1																	
**Myosotis caespitosa*																					1	
**Myosotis discolor*																					1	
Brassicaceae																						
**Brassica rapa* subsp. *sylvestris* C																						
Cardamine gunnii						1																
Cardamine paucijuga																					2	
**Lepidium africanum*			2																			
Rorippa laciniata						1																
Rorippa nasturtium-aquaticum E																						
**Rorippa palustris* B																						
**Sisymbrium officinale*			3																			
**Sisymbrium orientale*						1																
**Turritis glabra* C																						
Burmanniaceae																						
Burmannia disticha C																						
Cabombaceae																						
Brasenia schreberi E **(R)**																						+

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Campanulaceae																						
Wahlenbergia communis			2			3	2															
Wahlenbergia gracilis	2	2	1	1		3			1	4			1	1	2		1				5	
Wahlenbergia graniticola		1			2	1			2				1								2	
Wahlenbergia littoricola	1				1																	
Wahlenbergia luteola	6	9	11		4	1									2	1	1				1	
Wahlenbergia planiflora subsp. *longipila*	3	3	8		1	1	1	2	1				1		1				1			
Wahlenbergia planiflora subsp. *planiflora*	13	8	2		2		1							1	1						1	
Wahlenbergia queenslandica	2	4	4	2	3	1	2			1			1									
Wahlenbergia stricta subsp. *stricta*	3	10	14		3	14	1	4	6				6	3	21	10	2	1			4	
Caprifoliaceae																						
**Lonicera japonica*																1						
Caryophyllaceae																						
**Arenaria leptoclados*						2																
**Cerastium fontanum* subsp. *vulgare*	1	5	6		2	8	2								4	1		1			2	
**Cerastium glomeratum* C																						
**Dianthus armeria*	1		1		1	2															2	
**Paronychia brasiliana*	7	20	15	1	1	2	1	1							4	5					1	
**Petrorhagia nanteuilii*	6	8	7		3	10	1										1				2	
**Polycarpon tetraphyllum*		3	4			1															1	
Scleranthus biflorus	12	26	22	3	3	13	2	7	1					2	10	14	1				3	
**Silene gallica*						2											1					
**Spergularia rubra* B																						
Stellaria angustifolia			3		1		1									1					4	5
**Stellaria media*		1	5		1										2							
Stellaria pungens	1	4	5	2		5									5						1	
Casuarinaceae																						
Allocasuarina littoralis									3	12			5	2	5	1	1	1	3	1		
Allocasuarina rigida subsp. *rigida*									1						1				1			
Casuarina cunninghamiana C																						

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Celastraceae																						
Maytenus silvestris		1								2					3							
Centrolepidaceae																						
Centrolepis strigosa E																						
Chenopodiaceae																						
Atriplex semibaccata B																						
**Chenopodium album* B																						
Chenopodium carinatum		1																				
Chenopodium pumilio C																						
Einadia hastata	4	6	7							1					1	1						
Einadia nutans	5	4	6	1		1	1															
Clusiaceae																						
Hypericum gramineum	12	18	13	1	7	10	3	7	5	1			5	1	6	15	3				2	2
Hypericum japonicum																						1
**Hypericum perforatum*	1																					
Colchicaceae																						
Wurmbea dioica			2																			
Commelinaceae																						
Commelina cyanea C																						
Convolvulaceae																						
**Convolvulus arvensis*						1																
Convolvulus erubescens	1		6			1																
Dichondra repens	18	36	34	3	9	15	4	2	2	1			3	5	26	19	2	2			5	
Dichondra sp. A			1																			
Crassulaceae																						
Crassula helmsii																					1	
Crassula sieberiana	3	7	14	1	1	4	1						1	4	2	4			1		2	

Botanical Name	**Plant Community Number (number of sites)**																						
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Cyperaceae																						
Baumea nuda B																						
Baumea rubiginosa																		1			1	
Bulbostylis densa																					1	
Carex breviculmis	2	2	5		1			1		1		1	4	3	8	6		1				
Carex chlorantha																					1	
Carex fascicularis B																						
Carex gaudichaudiana						2							1		1						10	1
Carex incomitata			1			3									2	3			1		3	
Carex inversa	8	15	12	1	3	2	4	2	1							1	1				1	
Carex polyantha C																						
Carex tereticaulis																					1	1
Caustis pentandra					1																	
Cyperus difformis C																						
**Cyperus eragrostis*																			1			
Cyperus flaccidus E																						
Cyperus flavidus E																						
Cyperus gracilis		1																				
Cyperus gunnii C																						
Cyperus lhotskyanus																					1	
Cyperus lucidus																					5	
Cyperus sanguinolentus																					1	1
Cyperus sphaeroideus																					1	1
Eleocharis acuta																					2	6
Eleocharis dietrichiana																						1
Eleocharis gracilis																						1
Eleocharis pusilla C																						
Eleocharis sphacelata																					3	2
Fimbristylis dichotoma						1																
Gahnia aspera															1			1				

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Cyperaceae cont.																						
Gahnia sieberiana										+			1					1	1			
Isolepis cernua B																						
Isolepis fluitans E																						
Isolepis habra E																						
Isolepis hookeriana E																						
Lepidosperma gunnii									1	2									4			
Lepidosperma laterale			4	2					2	8			1	1	9			1	1	2	1	
Lepidosperma limicola																		1				
Lipocarpha microcephala E																						
Ptilothrix deusta																				1		
Schoenoplectus mucronatus																					1	
Schoenoplectus validus																					1	
Schoenus apogon	2		5		2	5	3	3	3				1	2	4	1		3			2	3
Scirpus polystachyus																					6	
Dilleniaceae																						
Hibbertia acicularis			1							3									2			
Hibbertia cistoidea							1															
Hibbertia linearis	11	14	16	5	13			1	4	6					2	4		1	4	2		
Hibbertia obtusifolia C																						
Hibbertia riparia	2	3			2			1	6	8	1					1		1	1	2		
Hibbertia rufa																		2				
Hibbertia serpyllifolia C																						
Hibbertia sp. B		2			1																	
Droseraceae																						
Aldrovanda vesiculosa E **(e)**																						+
Drosera burmannii E																						
Drosera peltata			3		3		1															
Drosera spatulata																		1				

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Elatinaceae																						
Elatine gratioloides																					2	
Epacridaceae																						
Brachyloma daphnoides	1	4			9			3	8	9						2					1	
Brachyloma saxicola										2								1	4	2		
Epacris breviflora																		3			2	
Epacris microphylla					1					1								4		1	3	
Epacris obtusifolia																		2				
Leucopogon biflorus			1		4																	
Leucopogon ericoides					1																	
Leucopogon fraseri		2	3				3	4	1							6	2					
Leucopogon lanceolatus var. *lanceolatus*		3	2	2				1	6	9	1	3	10		23	10			3			
Leucopogon melaleucoides ^{B}																						
Leucopogon microphyllus																			1			
Leucopogon muticus ^{C}																						
Leucopogon neo-anglicus																			4			
Leucopogon virgatus					1																	
Lissanthe strigosa	18	15	19	4	4	2	1				2				1	2	3					
Melichrus procumbens									2	3									2	1		
Melichrus urceolatus	10	14	10	3	11	2	1	1	5	2	1	1	5		1	1	1	1		1	1	
Monotoca scoparia		1		2	3			1	7	11		2	8		3	4		2	3	1	1	
Eriocaulaceae																						
Eriocaulon scariosum																		1			1	
Euphorbiaceae																						
Adriana tomentosa var. *tomentosa* ^{C}																						
Chamaesyce drummondii						1																
Monotaxis macrophylla ^{G} **(e)**																						
Phyllanthus subcrenulatus ^{C}																						
Phyllanthus virgatus	8	6	4			1	1	1	2				2			3					3	
Poranthera microphylla	11	22	21	5	12	13	2	6	10	12		3	10	2	12	13	3		1		4	
Pseudanthus divaricatissimus ^{G} **(R)**																						

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Fabaceae																						
Acacia brownii				1																		
Acacia brunioides subsp. *brunioides* **(R)**																			1			
Acacia buxifolia subsp. *buxifolia*					4																	
Acacia dawsonii		1																				
Acacia dealbata	5	5	9		4	13		2		1					5	6					1	
Acacia falciformis		1	2		1				2	5			3	1		1			4			
Acacia filicifolia	1	2	4						10	4			9		7	2	2			1	2	
Acacia fimbriata										2					5						3	
Acacia gunnii					5				1													
Acacia implexa	7	9	5	1		1									4	1	1					
Acacia irrorata ᶜ																						
Acacia leucolobia									1	1										2		
Acacia melanoxylon						2									1	1					1	
Acacia neriifolia					1																	
Acacia penninervis					1																	
Acacia rubida				1	4			1		2											1	
Acacia siculiformis	1							1														
Acacia stricta ᶜ																						
Acacia ulicifolia					1					3			1						1			
Acacia venulosa					3																	
Acacia viscidula ᶜ																						
Aotus subglauca									5	1									1	1		
Aotus subglauca var. *subglauca*					1			1		1			1					1				
Bossiaea neo-anglica									1	5			1							1		
Bossiaea prostrata				1																		
Bossiaea rhombifolia subsp. *rhombifolia*																			2			
Bossiaea scortechinii	1	2			4			1	10	9		2	3			2			1	1		
Crotalaria mitchellii subsp. *laevis*								1	1													
Cullen tenax		1				4																

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Fabaceae cont.																						
**Cytisus scoparius* ^{C}																						
Daviesia acicularis ^{C}																						
Daviesia elliptica ^{A} **(R)**									+													
Daviesia genistifolia	1	1				1																
Daviesia latifolia	1	3	1		5																	
Daviesia ulicifolia ^{A}		+																				
Desmodium brachypodum	4	6	2	2		1			1					2	2	3	1					
Desmodium varians	18	19	29	3	6	10	4	6	5	5		1	7	3	24	17	2				1	
Dillwynia juniperina ^{B}																						
Dillwynia phylicoides						1			6	4			1		1	1		2	4	1	1	
Dillwynia sieberi		2	1		1	3										2					1	
**Genista monspessulana*						1																
Glycine sp. nov.																					1	
Glycine microphylla ^{B}																						
Glycine clandestina	10	32	33	5	6	20	1	8	8	8	1	1	9	5	33	17	1	1	1		3	
Glycine tabacina	1	2	1			2			1							1						
Gompholobium huegelii					1	2			1	1												
Hardenbergia violacea	5	9	9	4	12	3		1	8	12	2	3	5	2	8	5	2		1			
Hovea beckeri										3									4	1		
Hovea lanceolata																			1			
Hovea linearis	2	2	2		7	5		1	9	2		1	5		1	4					1	
Hovea sp. A									2	4		2	1							1		
Indigofera adesmiifolia	1	1	3										2		1							
Indigofera australis	1	4	6	3	4	1			1		1				6	1	2					
Jacksonia scoparia	5	2	1						4	2			1	1							1	
Lespedeza juncea subsp. *sericea*	3	4	1			6	2	2	1					1		1					4	
Lotus australis	1	1	1			2																
**Lotus corniculatus*																					1	
Mirbelia confertiflora									2	4									4	2	1	
Pultenaea altissima										1			1									

Botanical Name	Plant Community Number (number of sites)																					
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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Fabaceae cont.																						
Pultenaea campbellii **(V, v)**	1	3			5																	
Pultenaea microphylla	6	7	2			9	2	2	1	1						4		2				
Pultenaea myrtoides																		1				
Sphaerolobium minus																		1				
Swainsona galegifolia C																						
Swainsona monticola A		+																				
Swainsona oroboides C																						
Swainsona parviflora		+			1		1															
Swainsona sericea			1					1														
**Trifolium arvense*	3	6	1		2	4	1	1													2	
**Trifolium campestre*	4	3	7		2	6	2	1									1					
**Trifolium glomeratum*	6	3	9		1	6	1							1	1		1				2	
**Trifolium pratense*						2															1	
**Trifolium repens*	7	18	13	1	6	18	2	5						2	15	16	2	1			8	2
**Trifolium striatum* E																						
**Vicia sativa* subsp. *angustifolia*					+	2																
**Vicia sativa* subsp. *sativa*																					1	
Zornia dyctiocarpa var. *dyctiocarpa*	1															1						
Gentianaceae																						
**Centaurium erythraea*	5	5	5	2	3	5	1	4	1	1			2		6	4					8	
Centaurium spicatum C																						
**Centaurium tenuiflorum*	1						1															
Geraniaceae																						
**Erodium moschatum* C																						
Geranium homeanum		1																				
Geranium potentilloides								+										2				
Geranium retrorsum E																						
Geranium solanderi var. *grande*																1						
Geranium solanderi var. *solanderi*	18	36	36	3	6	23	2	5	2				9	4	31	17	3	1			7	

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	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Goodeniaceae																						
Dampiera stricta C																						
Goodenia bellidifolia subsp. *argentea*		+							1													
Goodenia bellidifolia subsp. *bellidifolia*	1				7				1	1								1			1	
Goodenia gracilis	1			+																		
Goodenia hederacea subsp. *hederacea*	5	7	4		8	3		3	13	16	2	2	7	1	3	7	3	1	3	2	1	
Goodenia macbarronii B, 1917 **(V, v)**																						
Goodenia pinnatifida	1																					
Scaevola hookeri																		1			1	
Velleia paradoxa B																						
Haemodoraceae																						
Haemodorum planifolium									2	1												
Haloragaceae																						
Gonocarpus micranthus							1											3			2	
Gonocarpus micranthus subsp. *ramosissimus*																		1				
Gonocarpus tetragynus	2	9	4		9	3	2	6	12	13	1	1	8	2	6	9		1	1	1		
Gonocarpus teucrioides	1	1	1	1	1			1	2	1			1		2	3			2		1	
Haloragis heterophylla	8	4	8		2	3	3	1	1							8	2				4	
Myriophyllum aquaticum																					1	
Myriophyllum crispatum																					1	
Myriophyllum lophatum C																						
Myriophyllum simulans B																						
Myriophyllum variifolium																					8	6
Myriophyllum verrucosum C																						
Hydrocharitaceae																						
Vallisneria gigantea																					3	
Hypoxidaceae																						
Hypoxis hygrometrica var. *splendida*							1	1								+					1	

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Iridaceae																						
Patersonia fragilis C																						
Patersonia glabrata									2	7		2			1			1	3	2		
Patersonia sericea								1	3	9			1					1				
**Sisyrinchium iridifolium* E																						
**Sisyrinchium* sp. A E																						
Juncaceae																						
**Juncus articulatus*																					1	3
Juncus australis						1															3	
**Juncus bufonius* B																						
Juncus continuus															1						1	
Juncus falcatus B																						
Juncus filicaulis	3	1	4		1	1	4	1													1	2
Juncus flavidus																					1	
Juncus fockei																					1	4
Juncus holoschoenus C																						
Juncus homalocaulis	3							1														
Juncus laeviusculus subsp. *laeviusculus* A																			+			
Juncus ochrocoleus B																						
Juncus planifolius	1																					
Juncus prismatocarpus																					3	
Juncus sandwithii B																						
Juncus subsecundus	3	1	4		2		2														1	
Juncus usitatus						1	1														6	
Juncus vaginatus																						1
Luzula densiflora	3	9	13		3	8	3	3	1				2	1	9	11		1	1		1	
Luzula flaccida															1							
Juncaginaceae																						
Triglochin procera																					2	

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Lamiaceae																						
Ajuga australis	5	8	6	1	2	10	1		1	1			3	1	5	7					2	
Lycopus australis ᶜ																						
**Marrubium vulgare*	1	1	3			1									1						1	
Mentha satureioides	6	9	14	1		3	1	1					1		1	4	1					
**Mentha x piperita*																					2	
Plectranthus parviflorus	2		1											3	1				1			
Prostanthera nivea ᴮ																						
Prostanthera scutellarioides																			2			
**Prunella vulgaris*						1															6	
Scutellaria humilis		1	3																			
Lauraceae																						
Cassytha glabella					2																	
Cassytha pubescens					1																	
Lemnaceae																						
Lemna trisulca ᶜ																						
Spirodela punctata ᴱ																						
Lentibulariaceae																						
Utricularia australis																						1
Utricularia dichotoma																		1			1	3
Linaceae																						
Linum marginale ᴮ																						
Lobeliaceae																						
Isotoma axillaris													+						1			
Isotoma fluviatilis																					1	1
Lobelia gibbosa									1													
Pratia purpurascens													1		2	1						
Pratia surrepens																					2	4

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Loganiaceae																						
Logania albiflora															2	1					1	
Lomandraceae																						
Lomandra elongata C																						
Lomandra filiformis subsp. *coriacea*	4	3	5	5	7				5	1			1			2						
Lomandra filiformis subsp. *filiformis*			2		1	1			3	3			5		1				1	1		
Lomandra glauca					1																	
Lomandra longifolia	2	6	6	2		4		5	8	12	1	3	8	5	30	12	1	1	4	1	12	
Lomandra multiflora subsp. *multiflora*	6	4	5	2	4	3	2	3	3	4	2	2	6	3	4	2			1		1	
Loranthaceae																						
Amyema miquelii	3					2				2					1	1						
Amyema pendulum subsp. *pendulum*	6	1	2	1	1	2			1										1			
Muellerina eucalyptoides C																						
Luzuriagaceae																						
Eustrephus latifolius			1			1				1		1	2	2	7							
Geitonoplesium cymosum			1										1									
Lythraceae																						
Lythrum hyssopifolia E																						
Lythrum salicaria A																+						
Malaceae																						
Cotoneaster franchetii								2							1							
Crataegus monogyna			2			1																
Malus domestica		1						1														
Malvaceae																						
Modiola caroliniana			1				1														1	
Pavonia hastata C																						
Menyanthaceae																						
Nymphoides geminata																						3
Nymphoides montana C																						

Botanical Name	Plant Community Number (number of sites)																					
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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Myrsinaceae																						
Rapanea variabilis															1							
Myrtaceae																						
Angophora floribunda		3	5			1																
Baeckea gunniana									1									5		1	1	
Baeckea omissa													1								1	
Callistemon pallidus													2									
Callistemon pityoides																		3				
Calytrix tetragona																			1			
Eucalyptus acaciiformis		1							1	1						9	2	2	2		3	
Eucalyptus amplifolia subsp. *sessiliflora*										1												
Eucalyptus andrewsii					6														1			
Eucalyptus banksii				6	2	1																
Eucalyptus blakelyi	19	6	4		2		1	1						2								
Eucalyptus bridgesiana	3	6	8	2	1																	
Eucalyptus caliginosa	8	40	4		8	1			12	7			8	5	5	8	3		2	1	4	
Eucalyptus cameronii										3					2	2			1			
Eucalyptus campanulata										15					1							
Eucalyptus camphora subsp. *relicta* ^{B} **(V, e)**																						
Eucalyptus codonocarpa **(R)**																			3			
Eucalyptus dalrympleana subsp. *heptantha*		6	7	1	9	8	3	3	10			1	1		1	7	1				4	
Eucalyptus laevopinea	9		38	8	9						2			1	5	2						
Eucalyptus melliodora	18	14	13																			
Eucalyptus michaeliana ^{C} **(R)**																						
Eucalyptus moluccana	1	1																				
Eucalyptus nicholii **(V, v)**					3																	
Eucalyptus nobilis		2	1			2			1	3	2	2	7	3	24	3			1		1	
Eucalyptus nova-anglica	1	2			1	5	6	8					2		1	3		1			7	
Eucalyptus obliqua						1				1			2		26			1				

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Myrtaceae cont.																						
Eucalyptus pauciflora			1			14		6	2				1		1	7		1			6	
Eucalyptus prava					3																	
Eucalyptus radiata subsp. *sejuncta*		1	1		2	1			4	6	2	3	6		13	15	3			2		
Eucalyptus subtilior					2																	
Eucalyptus stellulata						9		5														
Eucalyptus viminalis		6	3	1		11																
Eucalyptus youmanii **(R)**	4				8																	
Kunzea obovata									1										4	1		
Kunzea parvifolia	1				1		+															
Leptospermum arachnoides C																						
Leptospermum brevipes	2				4			1	1	1									2	2	3	
Leptospermum gregarium	1				1			1								1		5			1	
Leptospermum minutifolium C																						
Leptospermum novae-angliae									1									2	6	2	1	
Leptospermum polygalifolium subsp. *transmontanum*			1		1			2	1	1			2		1	1					15	
Najadaceae																						
Najas tenuifolia E																						
Nyctaginaceae																						
Boerhavia dominii C																						
Oleaceae																						
Ligustrum sinense																1						
Ligustrum vulgare		1																				
Notelaea linearis									2	6					2				1	1	3	
Notelaea microcarpa					1																	
Notelaea sp. A A												+										
Onagraceae																						
Epilobium billardiereanum subsp. *cinereum*		4	3	1	1	8	1	4	1					1	1						10	3
Epilobium billardiereanum subsp. *hydrophilum*								1													1	
Epilobium gunnianum E																						

Botanical Name	**Plant Community Number (number of sites)**																					
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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Onagraceae cont.																						
Epilobium hirtigerum E																						
**Oenothera glazioviana* C																						
Orchidaceae																						
Acianthus exsertus													3		2							
Acianthus sp. aff. *exsertus* D																						
Bulbophyllum elisae									1						2				1			
Caladenia cucullata										1												
Caladenia fuscata												2	1		1	1						
Caleana minor					1																	
Calochilus campestris C																						
Calochilus gracillimus B																						
Calochilus robertsonii					1																	
Chiloglottis trapeziformis C																						
Corybas fimbriatus C																						
Dendrobium fairfaxii														1	3				1			
Dendrobium pugioniforme																			1			
Dipodium atropurpureum B																						
Dipodium punctatum A		?+																				
Dipodium variegatum			1																			
Diuris abbreviata						7						1				2						
Diuris dendrobioides						1																
Diuris pedunculata C **(E, e)**																						
Diuris punctata B																						
Diuris sulphurea C																						
Eriochilus cucullatus C																						
Gastrodia sesamoides C																						
Genoplesium nudum C																						
Glossodia major C																						
Microtis unifolia						1		1								1					1	

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Orchidaceae cont.																						
Orthoceras strictum																1						
Prasophyllum brevilabre C																						
Prasophyllum odoratum C																						
Pterostylis abrupta C																						
Pterostylis alata C																						
Pterostylis cycnocephala B																						
Pterostylis fischii C																						
Pterostylis longifolia													1			1						
Pterostylis mutica			1												+							
Pterostylis obtusa C																						
Pterostylis parviflora C																						
Pterostylis praetermissa									1													
Pterostylis rufa			1																			
Pterostylis sp. aff. *obtusa* D																						
Pterostylis sp. aff. *abrupta* D																						
Pterostylis truncata C																						
Spiranthes sinensis subsp. *australis*								1														
Thelymitra ixioides var. *ixioides*																		1				
Oxalidaceae																						
Oxalis exilis	6	11	13			4	2						1			1	1				2	
Oxalis perennans	5	2	4			2	1														1	
Oxalis radicosa	1	7	5	3	12		1	2	7	1			5		2	7	1				1	
**Oxalis thompsoniae*		1	3												1							
Papaveraceae																						
**Argemone ochroleuca* subsp. *ochroleuca* B																						
Phormiaceae																						
Dianella caerulea		2											1		2		1				2	
Dianella longifolia						1									1							
Dianella revoluta var *vinosa*	1		2						11	3			3		2	1						

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Phormiaceae cont.																						
Dianella tasmanica										3									2			
Stypandra glauca										2												
Thelionema grande ^{G} **(R)**																						
Phytolaccaceae																						
**Phytolacca octandra*										1					+							
Pittosporaceae																						
Billardiera scandens var. *scandens*		2	2	1	1	1		1	6	9		2	6	1	13	5			1		1	
Bursaria longisepala ^{C}																						
Bursaria spinosa	11	8	20	2		1		6	4	2			4	1	11						5	
Rhytidosporum procumbens		1			4				2	1										2	1	
Plantaginaceae																						
Plantago debilis						1																
Plantago gaudichaudii	7	6	3	1	1	4	2	1	1				2	2		1					1	
Plantago hispida	1	9	13	1	1	1	1		1	1			1	1	2						1	
**Plantago lanceolata*	8	9	2			6	3	1	1								2				4	
**Plantago scabra* ^{C}																						
Plantago varia ^{C}																						
Poaceae																						
Agrostis aemula							1															
**Agrostis capillaris*						1																
Agrostis avenacea var. *avenacea*		1				5	1														7	5
**Aira cupaniana*															1							
**Aira elegantissima*	5	4	12		7	3	4	3								1						
**Aira provincialis*		3				+																
Amphibromus nervosus																						1
Amphibromus pithogastrus ^{E}																						
Amphibromus sinuatus ^{C}																						
**Anthoxanthum odoratum*	3	6	8		2	7	3	2							9	8		1			2	1

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Aristida acuta																1						
Aristida calycina	3	1						3	3	3				3					1		2	
Aristida jerichoensis var. *subspinulifera*	5	3	4		4		1		1	2							1					
Aristida ramosa		4	6	2																	1	
Aristida ramosa var. *ramosa*	1	1	1																			
Aristida vagans		3	1		2	1										1	1					
Austrodanthonia bipartita ^{B}																						
Austrodanthonia caespitosa	1	1	1						2	2												
Austrodanthonia carphoides $^{B, 1931}$																						
Austrodanthonia eriantha $^{B, 1947}$																						
Austrodanthonia induta					1	1																
Austrodanthonia laevis	6	6	1	2	3	2							1			1	1				2	
Austrodanthonia monticola	1																					
Austrodanthonia penicillata		1				1																
Austrodanthonia pilosa var. *pilosa*	1		2	3				1	1				1		1	4					1	
Austrodanthonia racemosa var. *obtusata*	1	5	2	1												1						
Austrodanthonia racemosa var. *racemosa*	7	3	9		2	3	1	3	2				2		3	3					2	
Austrodanthonia richardsonii			1																			
Austrodanthonia tenuior		1	1		1				4	1			1					1			3	
Austrofestuca eriopoda ^{B}																						
Austrostipa densiflora					1																	
Austrostipa nodosa			2																			
Austrostipa pubescens										2											1	
Austrostipa rudis		1								1						1						
Austrostipa rudis subsp. *nervosa*	2	13	4	1	1	2		4	1		1		1	2	3	4					3	
Austrostipa rudis subsp. *rudis*	1		3		1																	
Austrostipa scabra subsp. *falcata*	3	4	2																			
Austrostipa scabra subsp. *scabra*			1																			
Austrostipa setacea $^{B, 1934}$																						

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Austrostipa verticillata			1																			
Bothriochloa biloba F, 1955 **(V, v)**																						
Bothriochloa decipiens C																						
Bothriochloa macra	12	11	9	4	2	1	1	1						2		2					1	
**Briza minor*	3		3		3		3														1	
**Bromus alopecuros* C																						
**Bromus brevis*			3			2	1								1	1						
**Bromus cartharticus*																					1	
**Bromus diandrus*			1			1																
**Bromus hordeaceus*	1	1	8		1	5	1	1							1	2					3	
Bromus molliformis	1				1	2									2							
Capillipedium parviflorum									1													
**Cenchrus incertus* C																						
Chloris truncata						1																
**Chloris ventricosa*			1																			
Cymbopogon refractus	3	7	8	2	2	1	1	1	3	2				5		1					1	
Cynodon dactylon		2				1								1	2	3					1	
Cynodon incompletus B																						
**Cynosurus cristatus*	2																					
**Cynosurus echinatus*	1					1																
**Dactylis glomerata*	1	2	2			1	1								1							
Deyeuxia acuminata										2												
Deyeuxia brachyathera										1											1	
Deyeuxia gunniana									5	1								1			1	
Deyeuxia imbricata																		1			1	
Deyeuxia parviseta					1					1												
Deyeuxia parviseta var. *parviseta*					1			1	6	6		1	4		2	2		1		1	2	
Deyeuxia quadriseta													1									
Dichanthium sericeum	1																					

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Dichelachne crinita	1	1	2			2		1								2					3	
Dichelachne inaequiglumis			1		1	1		2					2			2					1	
Dichelachne micrantha	11	20	12	5	9	4	1	4	12	10		2	6	5	9	4		1	1		2	
Dichelachne parva																		1				
Dichelachne rara		2	1		1	1		1								1					1	
Digitaria breviglumis									1						1							
Digitaria diffusa									1													
Digitaria ramularis										1											1	
**Echinochloa crus-galli*^{C}																						
**Echinochloa esculenta*^{C}																						
Echinopogon caespitosus var. *caespitosus*	4	2	2	1	6	1		1		1			1	1	3	3			1		1	
Echinopogon intermedius		2	3		2	3		3	2	2			1		5							
Echinopogon mckiei	2	3	2			2	1	3	2				1		1	2					2	
Echinopogon nutans var. *nutans*	1	4	3				1	3					2		2	2						
Echinopogon ovatus		2	11		1	2		1	1				1	1	2	1		2			2	
**Ehrharta calycina*^{C}																						
**Ehrharta erecta*^{C}																						
**Eleusine tristachya*			1																			
Elymus scaber	9	14	24	3	7	7	2	1	2	1			1		5	3					4	
Entolasia stricta			1		1	1			3	12		1	3		3	3	1		6	2	5	
Eragrostis benthamii			1					1	1												5	1
Eragrostis brownii^{C}																						
**Eragrostis cilianensis*^{C}																						
**Eragrostis curvula*^{C}																						
Eragrostis leptostachya	6	4	1											1								
Eragrostis molybdea^{C}																						
Eragrostis parviflora^{C}																						
Eragrostis trachycarpa^{E}																						
Festuca asperula^{B}																						
**Festuca elatior*	4	1	1		1	6		1							2	2	1				4	

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	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
**Festuca pratensis*		1				2	1								1		1				1	
Glyceria australis																						3
Glyceria latispicea ^{C}																						
Hemarthria uncinata var. *uncinata*						1															1	2
**Holcus lanatus*					1	5	1	4								2		1			7	4
**Hordeum hystrix*		1																				
**Hordeum leporinum*		1	2																			
**Hordeum marinum*			1			1																
Imperata cylindrica var. *major*	2	3	4		2	3		5	11	9			8	5	15	8			1		6	
Isachne globosa													1								5	
Joycea pallida				1	1	1				3												
**Lolium perenne*	2	2	2		1	2	1	1							1						1	
Microlaena stipoides var. *stipoides*	2	10	13	2	5	3	1	2	2	3			1		9	5	1				3	
**Nassella trichotoma* ^{B}																						
Panicum effusum									1													
**Panicum gilvum* ^{E}																						
Panicum obseptum ^{E}																						
**Paspalum dilatatum*						1	1									1					5	
**Paspalum distichum*																					1	
Pennisetum alopecuroides	1					3															4	1
**Pennisetum villosum* ^{C}																						
**Phalaris aquatica*		3	2			2																
**Phleum pratense* ^{B}																						
Phragmites australis																					2	
**Poa annua* ^{C}																						
Poa clivicola								1														
Poa costiniana					1	3		1														
Poa labillardierei			3		4	7	2	2	2						1	2	1				8	
**Poa pratensis*																1					1	
Poa sieberiana	18	38	34	5	7	13	3	6	5	12	2	3	10	4	32	20	2	1	3		7	

Botanical Name	Plant Community Number (number of sites)																					
	1	2	3	4	5	6/7	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Poaceae cont.																						
Sacciolepis indica C																						
Sorghum leiocladum	4	3		1	1	5	1	1	2	1						5					3	
Sporobolus creber	2	5	3				1	2	2												1	
Themeda australis	13	10	9	2	7	15	4	8	12	8		1	6	2	6	11	3	1			6	
**Vulpia bromoides*		2	1		3	7		1								1					2	
**Vulpia myuros*	5	7	17		1	5	2	1							2	6	1	1			1	
Polygalaceae																						
Comesperma ericinum C																						
Comesperma retusum																		2				
Comesperma volubile C																						
Polygala japonica		1				3							1	1		1						
Polygonaceae																						
**Acetosella vulgaris*		7	2		1	9		5	1						5	3					3	
**Fallopia convolvulus* C																						
Muehlenbeckia costata (ms) G **(K)**																						
Persicaria decipiens																					6	
Persicaria hydropiper																					1	
Persicaria lapathifolia C																						
**Persicaria maculosa* E																						
Persicaria prostrata																					1	
**Polygonum arenastrum*			1																			
Rumex brownii	9	24	25			6	3	2						2	5	6					6	
**Rumex conglomeratus*																						1
**Rumex crispus*																						1
Portulacaceae																						
Neopaxia australasica B																						
Potamogetonaceae																						
Potamogeton crispus C																						
Potamogeton ochreatus																					4	1

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Potamogetonaceae cont.																						
Potamogeton perfoliatus																					1	
Potamogeton tricarinatus																						4
Primulaceae																						
**Anagallis arvensis*	2		1														1					
Proteaceae																						
Banksia cunninghamii subsp. A									1	3					1			4		2		
Banksia integrifolia subsp. A									9	10		3	9	1	19	12		2	1		3	
Banksia marginata B																						
Grevillea juniperina								3													2	
Grevillea ramosissima B																						
Grevillea scortechinii subsp. *sarmentosa* **(V, v)**									2	4									2	2	1	
Hakea dactyloides									1										1	1		
Hakea eriantha										7		1	1		6							
Hakea microcarpa																		4			6	
Lomatia fraseri						3		3	1		1				2	2		4			3	
Lomatia silaifolia		1		1	5			1	6	17		3	5	2	11	1		2	2	1		
Persoonia cornifolia					3			2	11	11		2	8		4	3			1	2	2	
Persoonia oleoides													1									
Persoonia procumbens **(R)**									6	2			2							1		
Petrophile canescens									3	5								1		2		
Ranunculaceae																						
Clematis aristata		1	2										1		8	1					1	
Clematis glycinoides var. *glycinoides*	1	3	10	2		3							1	1	5	3						
Ranunculus inundatus																						3
Ranunculus lappaceus	3	6	7	2	1	13	2		2				3		11	4	2					
Ranunculus sp. A																					1	
Restionaceae																						
*Baloskion fimbriatum*B																						
Baloskion stenocoleum																		5		1	4	

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Restionaceae cont.																						
Empodisma minus																		1				
Lepyrodia anarthria																		4			1	
Rhamnaceae																						
Cryptandra amara var. *amara*			1																		1	
Cryptandra amara var. *longiflora*	1					1		1													1	
Cryptandra lanosiflora ^{G} **(R)**																						
Cryptandra propinqua ^{C}																						
Cryptandra scortechinii						1													1	2		
Discaria pubescens ^{C} **(R)**																						
Pomaderris andromedifolia ^{A}		+																			+	
Pomaderris eriocephala ^{A}	+																					
Pomaderris lanigera															1							
Pomaderris nitidula																					2	
Rosaceae																						
Acaena agnipila ^{B}																						
Acaena novae-zelandiae	3	20	27	1	2	13	1	8	2				5	3	24	17	2	1			5	
Acaena ovina	2	13	10	1	1	10	4	1								1	1				3	
**Potentilla recta* ^{B}																						
**Pyracantha angustifolia*																						
**Rosa rubiginosa*	6	14	10		2	7	3	2								5						
Rubus parvifolius	5	9	11	1	2	19	3	9	8	3			9	5	32	18	1				8	
**Rubus ulmifolius*		9	6		2	11	2	1							6	12		1			9	
**Sanguisorba minor* subsp. *muricata*																					1	
Rubiaceae																						
Asperula charophyton ^{A} **(R)**																						+
Asperula conferta	12	10	14		2	16	5	3	1					1	1	4	1				6	
Asperula gunnii																		2				
Coprosma hirtella ^{A}															+							
Galium binifolium			1		1																	

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Rubiaceae cont.																						
Galium ciliare	4	10	11	2		14		2	2	1			7	1	21	11					4	
Galium gaudichaudii		2	12	3	1	1				1			2		2	4						
Galium liratum															1						1	
Galium migrans	2	3	5												1	1						
Galium propinquum		7	9	3	2	1					1	1	3	1	2	1	1				1	
Leptostigma reptans ᴱ																						
Opercularia aspera	9	5	5	5	3		2		1		1		4		1	3	1					
Opercularia hispida	1	3	5	1	2			1	9	9			4	4	7	6	1				1	
Pomax umbellata									2	12			2		1							
Rutaceae																						
Boronia algida ᶜ																						
Boronia anemonifolia var. *anemonifolia*																			2			
Boronia anethifolia ᶜ																						
Boronia microphylla					1																	
Boronia polygalifolia	1		1																			
Correa reflexa var. *reflexa*	1				2					4		1			2				1			
Leionema ambiens ᴳ **(R)**																						
Phebalium squamulosum ᶜ																						
Zieria cytisoides										1												
Zieria fraseri subsp. B										1									1			
Zieria laevigata ᶜ																						
Zieria smithii subsp. A																			1			
Salicaceae																						
**Salix babylonica*																					1	
Santalaceae																						
Choretrum pauciflorum									6									1		2		
Exocarpos cupressiformis	1	1		2		5			1	2					2	1	1					
Exocarpos strictus		1				2																
Santalum obtusifolium															1							
Thesium australe **(V, v)**						4										1						

Botanical Name	Plant Community Number (number of sites)																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Sapindaceae																						
Dodonaea boroniifolia ^{C}																						
Dodonaea viscosa subsp. *angustifolia*		1								1									1			
Dodonaea viscosa subsp. *angustissima* ^{C}																						
Dodonaea viscosa subsp. *spatulata*					1				1	3					1				1		1	
Scrophulariaceae																						
Derwentia arcuata						1		1	1	3			1		1	1						
Derwentia derwentiana subsp. *derwentiana*															2						1	
Euphrasia orthocheila ^{F} **(R)**																						
Glossostigma diandrum ^{E}																						
Gratiola nana ^{B}																						
Gratiola peruviana									1												5	
Limosella australis ^{B}																						
**Linaria pelisseriana* ^{E}																						
Mimulus gracilis ^{E}																						
**Verbascum thapsus* subsp. *thapsus*	3	7	8	1	2	6				1											3	
**Verbascum virgatum* ^{B}																						
**Veronica arvensis*																					1	
Veronica calycina	7	22	27	3	11	7	1	4	5	3			7	1	18	15		1			2	
Veronica gracilis ^{B}																						
Veronica notabilis ^{C}																						
**Veronica peregrina*					1																	
Veronica plebeia	8	11	5	1	1	3	1						1	3	3	2	2	1	1			
**Veronica serpyllifolia* ^{A}																+						
Veronica sp. C																					1	
Smilacaceae																						
Smilax australis						4			1	1		2	1		22	5		1			1	
Solanaceae																						
**Datura stramonium* ^{C}																						
Solanum aviculare					1																	

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Solanaceae cont.																						
Solanum brownii						2							1		1							
**Solanum nigrum*		2				1		1							1			1				
Solanum opacum		2	1			3									2							
Solanum prinophyllum		1				1				1					2	2					1	
Stackhousiaceae																						
Stackhousia monogyna	3	5	2				1									1						
Stackhousia viminea	2	1	2		2	1				3			2			1			2			
Stylidiaceae																						
Stylidium graminifolium					5	1	1	5	12	7		1	4		1	2		2	2	1	1	
Thymelaeaceae																						
Pimelea curviflora var. *divergens*	8	7	11			3	1									1						
Pimelea glauca						1	1			1												
Pimelea ligustrina																					2	
Pimelea linifolia										1												
Pimelea linifolia subsp. *linifolia*	1	1	1		3	8		3	3	4								1	2	1	3	
Typhaceae																						
Typha domingensis c																						
Typha orientalis																					2	
Urticaceae																						
Urtica incisa	2	11	15		1	3									1						3	
Verbenaceae																						
**Verbena bonariensis*																					3	
Violaceae																						
Hybanthus monopetalus		8	4	1	9	6	1	1	1				1		2	5			1			
Hymenanthera dentata						4							1		1	1					2	
Viola betonicifolia	7	14	11	2	2	16	2	1	5	1			8	2	10	8	2		1		2	
Viola caleyana																					5	

Botanical Name	**Plant Community Number (number of sites)**																					
	1	**2**	**3**	**4**	**5**	**6/7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	(23)	(40)	(41)	(8)	(17)	(21)	(7)	(9)	(13)	(18)	(4)	(3)	(10)	(5)	(35)	(20)	(3)	(5)	(6)	(2)	(15)	(6)
Violaceae cont.																						
Viola hederacea	1		1		2	1				1			5		13	3		1			4	
Viola hederacea form d				1											1							
Winteraceae																						
Tasmannia stipitata ^A^															+							
Xanthorrhoeaceae																						
Xanthorrhoea glauca subsp. *glauca*		1	2		3													2				
Xyridaceae																						
Xyris gracilis subsp. *gracilis*													+					1				
Xyris operculata																		1				

VEGETATION OF BOOTI BOOTI NATIONAL PARK AND YAHOO NATURE RESERVE

Lower North Coast of New South Wales

1:25 000 Map Sheet

Produced by S.J.Griffith, R.Wilson and K.Maryott-Brown
for the New South Wales National Parks and Wildlife Service
to accompany
CUNNINGHAMIA VOLUME 6 NUMBER 3
2000.
Royal Botanic Gardens Sydney

	MAP CODE	COMMUNITY[#1]
		FORMATION: FOREST AND WOODLAND
		Subtropical rainforest
●	00031	*Livistona australis* simple, tall to very tall closed fan palm forest
		Littoral rainforest
●	05021	*Cupaniopsis anacardioides* simple, notophyll-microphyll, low to tall closed forest[#2]
●	05051	*Drypetes deplanchei* - *Sarcomelicope simplicifolia* subsp. *simplicifolia* - *Cassine australis* var. *australis* - *Podocarpus elatus* simple, notophyll-microphyll, low to very tall closed forest[#2]
		Dry rainforest
●	10031	*Ficus* spp. - *Streblus brunonianus* - *Dendrocnide* spp. - *Cassine australis* var. *australis* simple, notophyll, mid-high to tall closed forest[#2]
●	10041	*Choricarpia leptopetala* simple, notophyll, low to tall closed forest[#2]
		Mangrove woodland
●	25022	*Avicennia marina* subsp. *australasica* low to mid-high open woodland and woodland
		Wet sclerophyll forest
●	30021	*Lophostemon confertus* mid-high to very tall, open to closed forest
●	30041	*Eucalyptus grandis* very tall open to closed forest
●	30061	*Eucalyptus pilularis* very tall open to closed forest
●	30071	*Eucalyptus microcorys* very tall open to closed forest
●	30111	*Eucalyptus tereticornis* mid-high to very tall, open to closed forest
●	30121	*Eucalyptus fergusonii* subsp. *fergusonii* tall to very tall, open to closed forest
●	30131	*Corymbia maculata* - *Eucalyptus fergusonii* subsp. *fergusonii* - *E. acmenoides* very tall open to closed forest
		Dry sclerophyll forest and woodland
●	35041	*Eucalyptus pilularis* tall to very tall, open to closed forest[#3]
●	35081	*Eucalyptus microcorys* mid-high to very tall, open to closed forest
●	35121 35122	*Eucalyptus tereticornis* mid-high to tall, open woodland to closed forest
●	35131	*Allocasuarina littoralis* low open to closed forest
●	35221 35222	*Angophora costata* mid-high to very tall, open woodland to closed forest
●	35561 35562	*Eucalyptus pilularis* – *Angophora costata* tall to very tall, woodland to closed forest
●	35591	*Corymbia maculata* – *Eucalyptus fergusonii* subsp. *fergusonii* – *E. acmenoides* mid-high to tall, open to closed forest
●	35601	*Eucalyptus tereticornis* – *E. microcorys* mid-high to very tall, open to closed forest
	35611[#6]	*Angophora floribunda* low to mid-high, open to closed forest
●	35621	*Corymbia maculata* tall to very tall, open to closed forest
		Swamp sclerophyll forest and woodland
●	40031 40032	*Melaleuca quinquenervia* mid-high to very tall, open woodland to closed forest
●	40051 40052	*Casuarina glauca* mid-high to very tall, open woodland to closed forest
●	40981 40982	*Eucalyptus robusta* – *Melaleuca quinquenervia* mid-high to very tall, open woodland to closed forest
●	40991 40992	*Melaleuca quinquenervia* – *Casuarina glauca* mid-high to very tall, open woodland to closed forest
		FORMATION: MALLEE WOODLAND
		Dry sclerophyll mallee woodland
●	50022	*Eucalyptus pilularis* very tall to extremely tall, mallee woodland and open mallee woodland
		Swamp sclerophyll mallee woodland
●	51022	*Eucalyptus robusta* very tall to extremely tall, mallee woodland and open mallee woodland
		FORMATION: SHRUBLAND (SCRUB)
		Rain-shrubland
●	52031	*Choricarpia leptopetala* simple, notophyll, tall to very tall closed shrubland[#2]
		Dry sclerophyll shrubland
●	54021	*Banksia aemula* tall to very tall, open to closed shrubland
●	54041	*Melaleuca armillaris* very tall closed shrubland
●	54101	*Leptospermum laevigatum* tall to very tall closed shrubland
	54111[#7]	**Chrysanthemoides monilifera* subsp. *rotundata* - *Acacia sophorae* mid-high to tall closed shrubland
		Swamp sclerophyll shrubland
●	55062	*Melaleuca quinquenervia* tall to very tall, sparse to open shrubland
		FORMATION: HEATHLAND
		Dry heathland
●	58041	*Banksia aemula* - *Allocasuarina simulans* mid-high to tall closed heathland
●	58991	Intermediate dry heathland (mid-high to tall closed heathland)[#4]
		Graminoid clay heathland
●	59051	*Banksia spinulosa* var. *collina* - *Allocasuarina littoralis* - *Hakea teretifolia* - *Ptilothrix deusta* - *Themeda australis* low to mid-high closed heathland
		Wet heathland
●	60021	*Banksia oblongifolia* - *Leptospermum liversidgei* - *Sporadanthus interruptus* - *Sprengelia sprengelioides* - *Xanthorrhoea fulva* mid-high to tall closed heathland[#5]
		FORMATION: CHENOPOD SHRUBLAND
●	61021	*Sarcocornia quinqueflora* subsp. *quinqueflora* - *Sporobolus virginicus* dwarf to low, open to closed chenopod shrubland/tussock grassland
		FORMATION: TUSSOCK GRASSLAND
	62021[#7] 62022[#7]	*Spinifex sericeus* low to mid-high, sparse to closed tussock grassland
		FORMATION: SOD GRASSLAND
	63021[#6]	*Themeda australis* low to tall closed sod grassland
		FORMATION: SEDGELAND
●	64021	*Baumea juncea* mid-high to tall closed sedgeland
●	64031	*Leptocarpus tenax* - *Baloskion pallens* - *Schoenus brevifolius* tall to very tall closed sedgeland
		FORMATION: RUSHLAND
●	65021	*Juncus kraussii* subsp. *australiensis* tall to very tall closed rushland
●	65031	*Phragmites australis* very tall closed rushland
		VEGETATION COMPLEXES
●	90100	Foredune Complex: the main constituent communities are 54101, 54111 and 62021/2, although limited areas of 05021 and 40031 are also likely. Other species may dominate over small areas (e.g. *Banksia integrifolia* subsp. *integrifolia*, *Carex pumila*, *Lomandra longifolia*, *Scaevola calendulacea*, *Zoysia macrantha*). **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent, and **Casuarina equisetifolia* subsp. *incana* has been planted at some locations. Much of the complex is regeneration following sand mining.
●	90200	Saltmarsh Complex: the main constituent communities are 61021, 64021 and 65021, with small areas of 25022, 65031 and unvegetated mudflat also likely. Other species may dominate over minor localised areas (e.g. *Paspalum vaginatum*, *Schoenoplectus litoralis*).
●	90300	Headland Complex: the main constituent communities are 35131, 35611, 40051, 54041 and 63021. Limited occurrences of 00031, 05021, 05051, 10041, 40031, 52031 and 54101 are also likely. On very exposed aspects, forest communities may grade into shrublands. Other species can dominate over small areas (e.g. *Banksia integrifolia* subsp. *integrifolia*, *Westringia fruticosa*). **Chrysanthemoides monilifera* subsp. *rotundata* is prevalent, and exotic grasses (e.g. **Pennisetum clandestinum*) occur as localised infestations.
		MISCELLANEOUS MAP UNITS
●	91020	Beach sand, mobile sand (occasionally sandy tidal flats)
●	91030	Rock
●	91040	Open water (dam)
●	92020	Partially cleared
●	92030	Cleared
●	92040	Disturbance associated with past mining (includes quarries)
●	92060	Picnic or camping area
●	92070	Disturbance associated with roads
●	92080	Disturbance associated with transmission line
●	92090	Urban or residential development and associated infrastructure (includes housing, public works etc.)

Comments:

#1 The structural classification follows Walker and Hopkins (1984). The communities are named after dominant indicator species of the tallest (dominant) stratum, and most could be considered associations using the definition of Beadle (1981): 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'. Five-digit numeric codes are used for mapping purposes to identify individual plant communities, and also other map units such as cleared land. The first four digits of each code identify the formation, subformation and community. A fifth digit is used on the vegetation map to signify the crown cover range of the tallest stratum: 1 = mid-dense to dense (e.g. open to closed forest); 2 = very sparse to sparse (e.g. open woodland to woodland); 0 = crown cover variable, or else not determined. The '0' code is only used for 'complex' map units and 'miscellaneous' map units. In some instances it was not possible to map communities discretely at a scale of 1: 25,000. This situation arose where communities were too fragmented and intermixed (e.g. along foredunes and sea cliffs), or else formed seemingly broad ecotones or 'mixed stands' (after Beadle 1981). In some situations where communities closely intermix, micro-relief varies over small distances. For simplicity of mapping, commonly encountered mixed stands which are perceived to comprise two communities have been assigned a distinct map code (i.e. 40981/2 and 40991/2). Less common mixed stands are simply mapped using a dual code (e.g. 64021/65031). Fragmented and intermixed vegetation which comprises more than two communities is often found on foredunes, in saltmarshes, and along seacliffs. In such situations appropriately annotated complex map units are employed.

#2 This community has been named after the equivalent suballiance circumscribed by Floyd (1990).

#3 Unlike community 35561/2 (which is found on deep sands, and commonly referred to as 'Sandhill Blackbutt'), this community occurs on bedrock sites.

#4 Intermediate dry heathland supports a mixture of typical 'wet heathland' (60021) and 'dry heathland' (58041) species, and is a feature of very deflated sandplains on the NSW North Coast which display little or no slope and aspect. Where the topography becomes more pronounced, intermediate dry heathland is replaced by dry heathland upslope on dunes and beach ridges, and by wet heathland downslope in swales.

#5 Given a favourable fire regime, recruitment of the obligate seeder *Banksia ericifolia* var. *macrantha* may occur in wet heathland. *Banksia ericifolia* var. *macrantha* can in time overtop other species to form dense stands of shrubland.

#6 This community has not been mapped separately but included in 90300.

#7 This community has not been mapped separately but included in 90100.

Reference notes (used to identify features which are too small to map, but nonetheless of interest):

- ● A A small stand of 10031 is present.
- ● B *Melaleuca quinquenervia* is present as an emergent in excess of 5% of total crown cover for the tallest stratum.
- ● C *Angophora costata* is locally absent.
- ● D *Allocasuarina simulans* is locally absent.
- ● E *Corymbia maculata* is locally abundant in places.
- ● F *Eucalyptus grandis* and *Corymbia intermedia* are locally abundant in places.
- ● G A small stand of *Angophora costata* is present, and this is probably a remnant of a larger stand which originally extended onto what is now a picnic area.
- ● H This is a very degraded stand of *Angophora costata* with associated *Banksia serrata* which appears to have suffered from frequent fire and exposure. This stand may have originally been 35561.
- ● I Small stands of *Eucalyptus tereticornis* - *E. microcorys* forest fringe the lake foreshore.
- ● J Localised stands of *Eucalyptus pilularis* wet sclerophyll forest (30061) are present.
- ● K Rainforest species are locally common in association with *Casuarina glauca*.

Aerial photography:

Bulahdelah 1: 25,000 Colour (NSW 4037). Runs 6,7,8,9. Flown 14.9.1991. NSW Department of Land & Water Conservation.

References:

Beadle, N.C.W. (1981) *The vegetation of Australia.* (Cambridge University Press: Cambridge).
Floyd, A.G. (1990) *Australian rainforests in New South Wales.* Volumes 1-2 (Surrey Beatty and Sons - NSW National Parks & Wildlife Service: Chipping Norton).
Walker, J. & Hopkins, M.S. (1984) Vegetation. In R.C. McDonald, R.F. Isbell, J.G. Speight, J. Walker & M.S. Hopkins (eds) *Australian soil and land survey field handbook.* pp. 44-67. (Inkata Press: Melbourne).

Air photo interpretation and mapping by R. Wilson. Botany by S.J. Griffith and K. Maryott-Brown.

Community 52031: *Choricarpia leptopetala* rain-shrubland, northern end of the Cape Hawke hill complex.

Community 64021: *Baumea juncea* sedgeland near Green Point, last burnt in late January 1997. Also note crown fire damage to *Melaleuca quinquenervia* (background).

Community 35221: *Angophora costata* dry sclerophyll forest on a sand mantle over bedrock, southern end of the Cape Hawke hill complex.

Community 60021: *Banksia oblongifolia* - *Leptospermum liversidgei* - *Sporadanthus interruptus* - *Sprengelia sprengelioides* - *Xanthorrhoea fulva* wet heathland, with *X. fulva* prominent following a severe fire in late January 1997.

Community 58041: *Banksia aemula* - *Allocasuarina simulans* dry heathland, recovering from a severe fire in late January 1997.

Community 05051: *Drypetes deplanchei* - *Sarcomelicope simplicifolia* subsp. *simplicifolia* - *Cassine australis* var. *australis* - *Podocarpus elatus* littoral rainforest, southern end of the Cape Hawke hill complex.

Community 35591: *Corymbia maculata* – *Eucalyptus fergusonii* subsp. *fergusonii* – *E. acmenoides* dry sclerophyll forest, southern end of the Cape Hawke hill complex.

Community 54111: **Chrysanthemoides monilifera* subsp. *rotundata* - *Acacia sophorae* dry sclerophyll shrubland, north of the Booti Hill hill complex (background).

Community 40031: *Melaleuca quinquenervia* swamp sclerophyll forest, last burnt in late January 1997.

Community 35121: *Eucalyptus tereticornis* dry sclerophyll forest, northern end of the Booti Hill hill complex.

Community 63021: *Themeda australis* sod grassland with scattered emergent *Banksia integrifolia* subsp. *integrifolia* and *Westringia fruticosa*, on an exposed seaward slope of the Booti Hill hill complex.

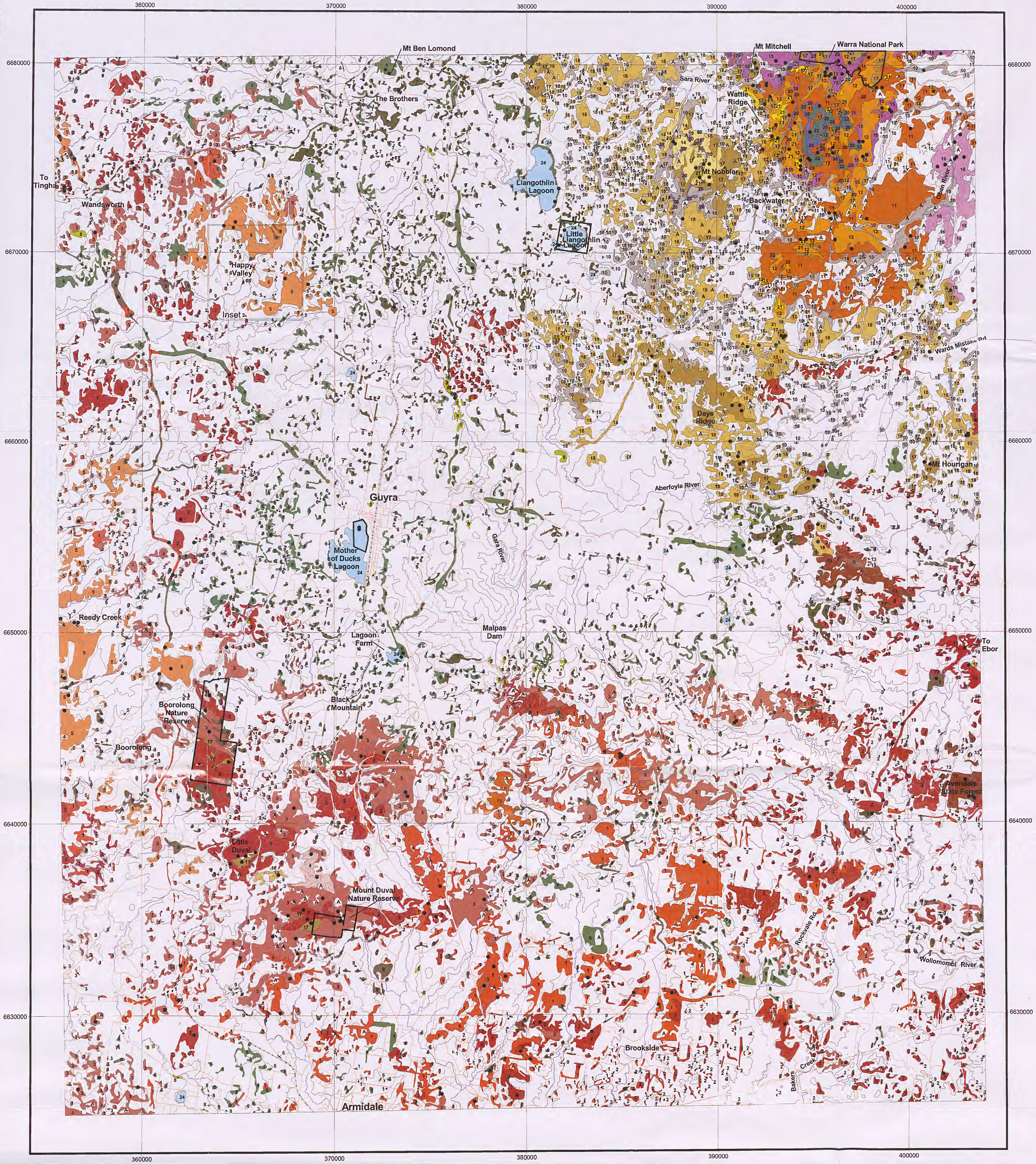
Community 35041: *Eucalyptus pilularis* dry sclerophyll forest on bedrock, southern end of the Booti Hill hill complex.

Community 00031: *Livistona australis* subtropical rainforest (fan palm forest) at Shelly Beach, last burnt in the 1994/95 fire season.

Grid lines are shown at intervals of 1000 metres from the False Origin - Zone 56 Australian Map Grid UTM

Cadastral information shown on this map is diagrammatic only

GUYRA 1:100 000 VEGETATION SERIES



Plant Communities

(Shown in the same order as that in the numerical analysis)

- 🟥 1. *Eucalyptus blakelyi - E. melliodora* Open Forest mainly on sediments
- 🟥 2. *Eucalyptus caliginosa* Open Forest on various substrates, mainly sediments
- 🟥 19. *Eucalyptus acaciiformis - E. caliginosa - E. radiata* subsp. *sejuncta* Open Forest on sediments
- 🟥 3. *Eucalyptus laevopinea* Open Forest on various substrates
- ⬜ 4. *Eucalyptus banksii - E. laevopinia* Open Forest mainly on acid volcanics
- 🟧 5. *Eucalyptus youmanii - E. andrewsii - E. subtilior* ± *E. nichollii* Open Forest on acid volcanics
- 🟩 6. *Eucalyptus viminalis - E. dalrympleana* subsp. *heptantha - E. pauciflora* Tall Open Forest - grassy understorey on basalt
- 🟫 7. *Eucalyptus stellulata - E. pauciflora* Low Open Forest or Low Open Woodland - grassy understorey, mainly basalt
- 🟫 9. *Eucalyptus nova-anglica* Woodland mainly on sediments and acid volcanics
- ⬜ 10. *Eucalyptus nova-anglica - E. pauciflora* Open Forest on granite and leucogranite
- 🟩 8. *Eucalyptus nova-anglica* Woodland on basalt
- 🟧 11. *Eucalyptus caliginosa - E. dalrympleana* subsp. *heptantha* Open Forest on leucogranite
- 🟧 12. *Eucalyptus campanulata* Open Forest on leucogranite
- 🟫 13. *Eucalyptus laevopinea - E. nobilis* Open Forest on sediments
- 🟨 14. *Eucalyptus radiata* subsp. *sejuncta - E. nobilis - Hovea sp. A* Open Forest on granite
- 🟪 15. *Eucalyptus nobilis - E. caliginosa* Open Forest on leucogranite
- 🟪 16. *Eucalyptus caliginosa - E. nobilis - E. blakelyi* Open Forest, Oban River on granite
- 🟫 17. *Eucalyptus obliqua - E. nobilis* Tall Open Forest on protected sites on various substrates
- 🟨 18. *Eucalyptus radiata* subsp. *sejuncta - E. acaciiformis* Open Forest on granite
- 🟪 20. Heath Swamps on leucogranite and granite
- 🟨 21. Mallee and Heath on rocky outcrops on leucogranite
- 🟩 22. *Eucalyptus radiata* subsp. *sejuncta - E. caliginosa* Open Forest with Dense Shrubland on leucogranite
- 🟦 24. Basalt Plateau Lagoons
- ⬜ A. Agricultural land cleared of woody vegetation or thinned >75% of pre-1750 density

(Note: 23. New England Riparian Shrubland not shown due to its narrow width lining creeks on various substrates)

Natural Vegetation

of the

GUYRA
(New South Wales)

1:100 000 Map Sheet

John S. Benson
Elizabeth M. Ashby

Descriptions of the plant communities are given in *Cunninghamia* 6 (3) 2000

Compiled and prepared at the National Herbarium of New South Wales

ROYAL BOTANIC GARDENS SYDNEY

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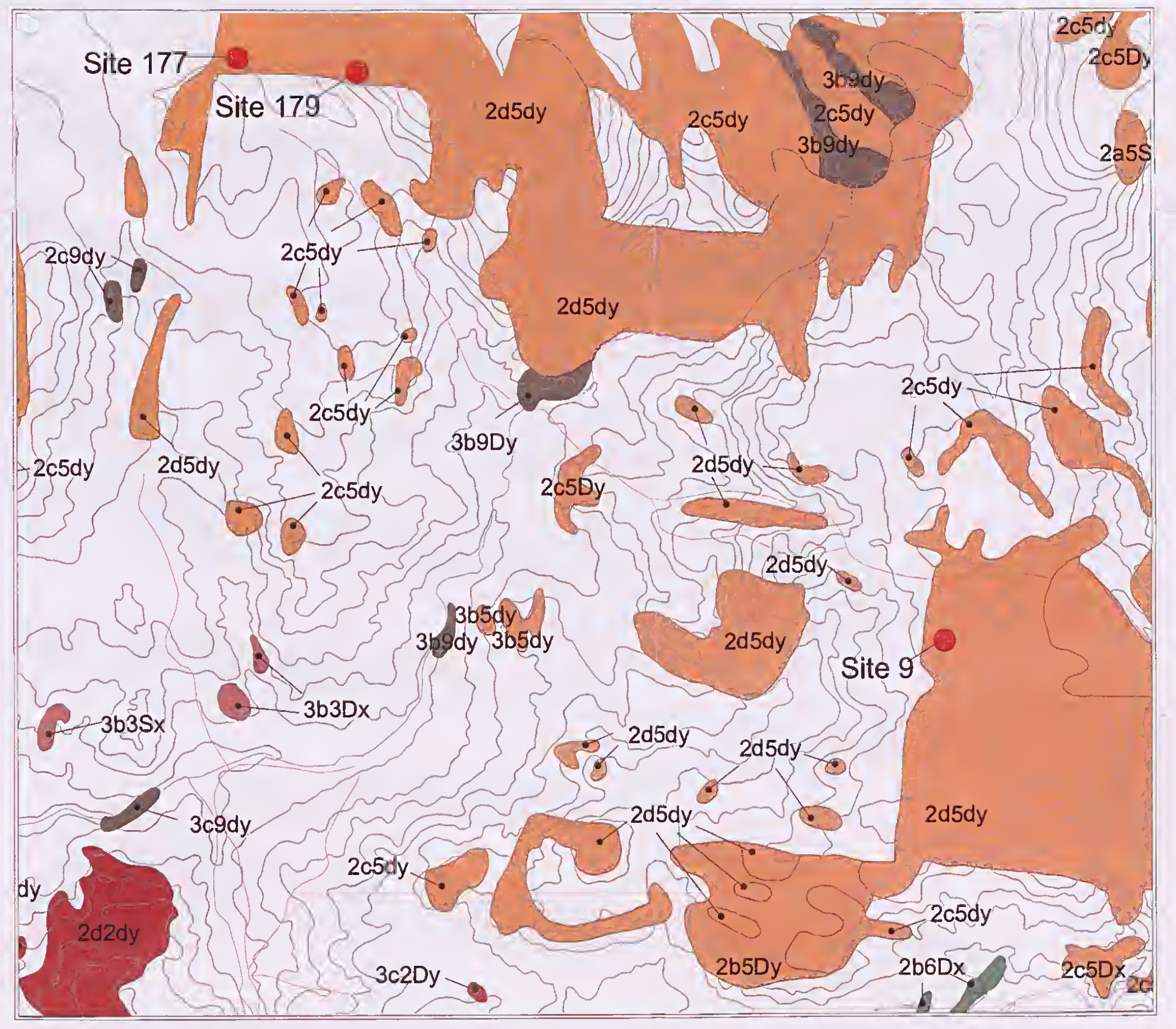
Inset



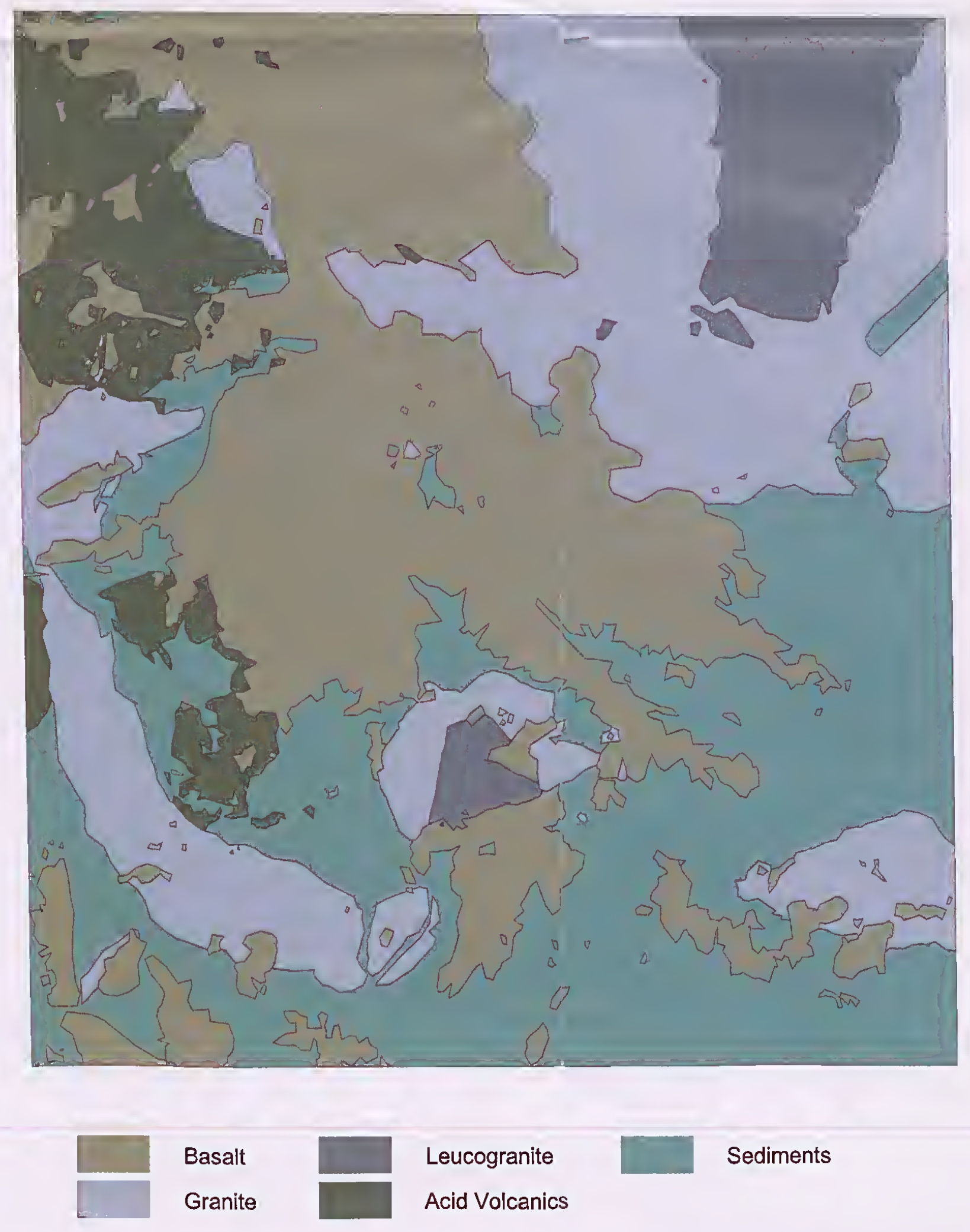
Example of detail contained within 1:25 000 source maps. The alphanumeric vegetation codes describe (in order) the height category of the overstorey, crown cover density, plant community, disturbance estimate and understorey type. This is the level of detail available in ArcView 3.1 format from the Royal Botanic Gardens Sydney.

Key to adjoining 1:100 000 maps

Inverell 9138	Glen Innes 9238	Newton Boyd 9338
Bundarra 9137	***Guyra*** ***9237***	Ebor 9337
Bendemeer 9136	Armidale 9236	Carrai 9336

Simplified Geology map

(derived from Guyra 1:100 000 Geological map, Dept Mineral Resources)



Key to other features

- Roads
- Railway
- Main Rivers & Creeks
- Contours, 50 m
- National Parks & Nature Reserves
- ● Sample sites

Vegetation boundaries based on interpretation of 1:25000 1989 colour aerial photography (NSW 3680,3682 & 3685). More recent clearing was detected (and mapped) during field traverses from 1992 to 1997.

Base Mapping (1:25 000, Australian Geodetic Datum 1966)
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Vegetation Survey of the Barrington Tops and Mount Royal National Parks for use in Fire Management **Toivo Zoete** 511

Estuarine wetlands distribution along the Parramatta River, Sydney, 1788–1940: implications for planning and conservation **Lynette C. McLoughlin** 579

Surveys of areas having potentially high botanical diversity near Pooncarie, South Far Western Plains **AnneMarie Clements, Tony Rodd, Rosalind J. Moore, Adele G. Crane and John Simpson** 611

Vegetation and flora of Booti Booti National Park and Yahoo Nature Reserve, lower North Coast of New South Wales. **S.J. Griffith, R. Wilson and K. Maryott-Brown** 645

Vegetation, soils and management of 'Zara': a sandhill remnant on the Riverine Plain **M.J. Stafford and D.J. Eldridge** 717

Vegetation of the Guyra 1: 100 000 map sheet New England Bioregion, New South Wales **J.S. Benson and E.M. Ashby** 747